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PAPERS ACCEPTED FOR PUBLICATION:

The Velocity of the Reaction between Silver Acetate and Sodium Formate. A Reaction of the Third Order. By Arthur A. Noyes and George T. Cottle.

Analytical Research on Sod Oil. By Erastus Hopkins, D. L. Coburn, and Edw. Spiller.

Notes on the Rapid Determination of Tungsten in Steel. By Geo. Auchy.

The Determination of Carbon Monoxide, Methane, and Hydrogen by Combustion. By L. M. Dennis and C. G. Hopkins.

A New Apparatus for the Determination of Volume. By C. F. McKenna.

A New Filtering Medium. By George Wm. Sargent and Jno. Kirk Faust.

Coumarin and Vanillin: Their Separation, Estimation, and Identification in Commercial Flavoring Extracts. By William H. Hess and Albert B. Prescott.

Emetine Octoiodide and the Extraction and Estimation of Alkaloids Generally. By H. M. Gordin and A. B. Prescott.

On the Isourea Ethers and Other Derivatives of Ureas. By F. B. Dains.

Note on a Convenient Method for Maintaining Reduction of Ferrous Solutions. By William S. Myers.

Perhalides of Quinoline. By P. F. Trowbridge.

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THE JOURNAL

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AMERICAN CHEMICAL SOCIETY.

A NEW GAS.

BY CHARLES F. BRUSH.[1]

Received October 25, 1898.

THE purpose of this purely preliminary paper, is to announce the discovery of a new gas; presumably elementary, and possessed of some extraordinary properties. It is a constituent of the atmosphere, and is occluded by many substances. Its chief characteristic thus far ascertained, is enormous heat conductivity at low pressures. In order to appreciate this phenomenon, it is necessary to consider the heat conductivity of some of the well-known gases.

A year ago, I had the honor to read before this section a paper on the transmission of heat by gases, illustrated by numerous curve sheets showing the heat conductivity of several gases at all pressures, from atmospheric down to the best vacuum obtainable; also an allied paper on the measurement of small gaseous pressures. Abstracts of these papers appear in the current volume of *Transactions*, and their full text may be found in the *Philosophical Magazine*, for January, 1898, and November, 1897, respectively.

The apparatus used for the described experiments in heat transmission, consisted in part, of a long-stemmed thermometer hanging in a long-necked glass bulb, the bulb of the thermometer being in the center of the glass bulb. Two bulbs were used for different experiments; the larger one 112 mm. in diameter,

[1] Read before the American Association for the Advancement of Science, August 23, 1898.

the smaller one only 20 mm. A tank of water and crushed ice under the bulb was adapted to be raised when desired, so as to immerse the bulb in the cold mixture. The neck of the bulb was connected with an air-pump capable of reducing the internal pressure to a very small fraction of a millionth of atmospheric pressure; also with an elaborate pressure-gauge adapted to measure small pressures with very great precision, and a barometric gauge for measuring larger pressures.

In using this apparatus, the gas to be tested was introduced at atmospheric pressure; the ice-tank was raised and the falling temperature of the thermometer, which could lose heat only by radiation, conduction, and convection through the surrounding gas, was observed through a telescope. The time required for the temperature to fall through a given range, usually from 15° to 10° C., was carefully noted. Then the ice-tank was lowered, permitting the thermometer to regain the temperature of the laboratory; some of the gas was pumped out, and the cooling of the thermometer again observed at this reduced pressure. This process was repeated many times, until the pressure was reduced to the lowest point attainable.

The results obtained with each gas were plotted in a curve showing its heat conductivity at all pressures from atmospheric down, the ordinates representing the reciprocals of the time of cooling in seconds, while the abscissas represented the pressure.

The present chart shows curves representing the heat conductivity of several gases, from fifty millionths of atmospheric pressure downward. The data for all of these except the helium curve, are taken from last year's paper; but the scale is different.

I am indebted to Prof. Ramsay for the helium used in obtaining the curve here shown.

The ordinates of each curve measured from A B as a base line, represent the total rate of heat transmission by the ether and the gas at the pressures indicated by the abscissas, while ordinates measured from the line C D, represent the heat transmitted by the gas alone.

It will be observed that the curves of all the gases named, vanish together at the point of zero pressure D. Repeated experiments have shown this condition to be always strictly true within

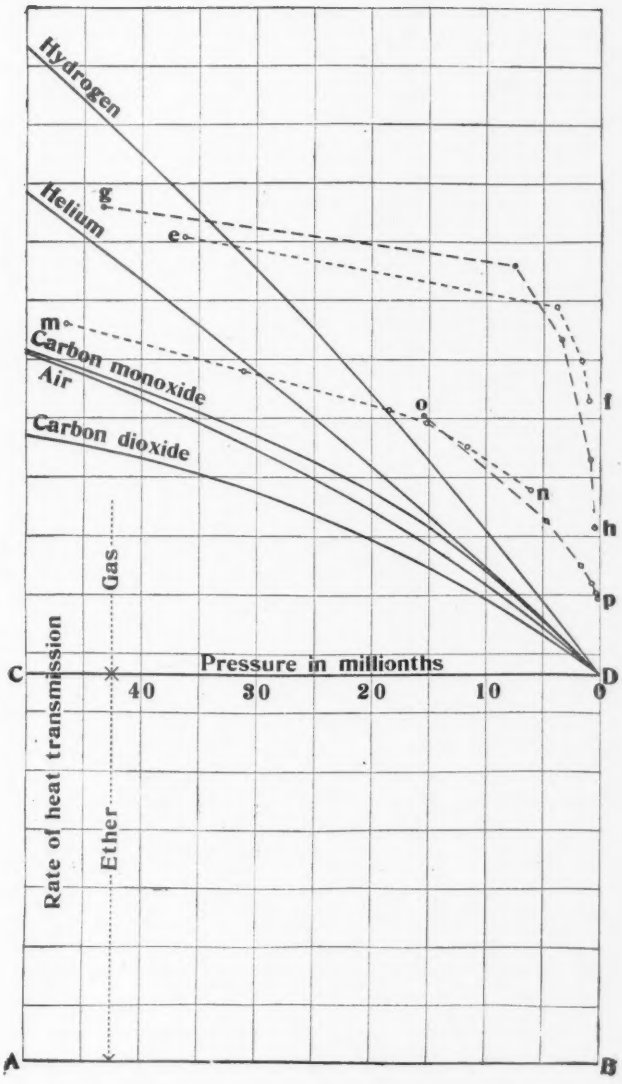


CHART SHOWING THE RELATIVE HEAT CONDUCTIVITY OF GASES.

the narrow limits of errors of observation, *provided* that before the introduction of the gas to be tested, the whole apparatus has been kept highly exhausted for several days; or better still, has been heated several hours by means of air- and water-baths, while kept exhausted. Without one of these precautions, I was never able to get any gas curve quite down to the point D, for reasons which will appear. The point D represents a period of 300 seconds required for the temperature of the thermometer to fall from 15° to 10°, with the pressure of the surrounding gas reduced to one twenty-millionth or less.

A very brief account of the circumstances which led to the discovery of the new gas may not be out of place. I had long been engaged in high vacua experiments, and had observed that glass apparatus when highly exhausted and heated, evolved gas for an indefinite length of time—rapidly at first, then slower, but never stopped until the temperature was reduced. On cooling, rapid reabsorption always took place, but was never complete, indicating that two or more gases had been evolved by heating, one of which was not absorbed on cooling. In other words, the absorption was selective. The truth of this conclusion was abundantly demonstrated subsequently. However, the percentage of reabsorbed gas was so large, that I used a small quantity of pulverized glass in several experiments, to absorb a part of the residual gas after the highest attainable exhaustion was reached. The pulverized glass was always lead glass like that of the apparatus, and was heated nearly red hot for several hours before and during the final exhaustion.

During these experiments a curious phenomenon was noted; the pulverized glass lost its snowy whiteness. This, I thought, must be due to reduction of some of its lead; probably by hydrogen evolved on heating. If so, I argued that the hydrogen must have been absorbed from the atmosphere since the manufacture of the glass; and its presence in the glass, if proven, would be a long step toward proving the normal presence of hydrogen in the atmosphere.

Following the line of experiment thus suggested, I prepared a quantity of pulverized soda glass free from lead, and placed about 120 grams of it in a large combustion tube connected with the apparatus already described. The glass was made from an

old stock of tubing, and was of such a degree of fineness that it all passed through a sieve of 90 meshes to the linear inch, but would not pass through a 140-mesh sieve. The combustion tube was adapted to be heated by a gas furnace with automatically regulated gas supply, so as to be maintained at any desired temperature.

While prepared to make analysis, in the usual way, of the gas evolved by the pulverized glass in case it appeared in sufficient quantity, I relied chiefly on its heat conductivity for the detection of any large proportion of hydrogen in the last few millionths, not being prepared at that time for spectroscopic examination; and thinking that perhaps some hydrogen might be evolved in the last stages of exhaustion before heating, I tested the conductivity of the residual air from time to time as the preliminary exhaustion progressed.

When the exhaustion approached a good vacuum, an astounding phenomenon developed. At 36 millionths pressure the residual gas conducted heat twice as well as air, and nearly as well as hydrogen; at 3.8 millionths it conducted seven times as rapidly as hydrogen; at 1.6 millionths, fourteen times, and at 0.96 of one millionth, twenty times as rapidly. These results are plotted in the curve *e f*. I did not carry the exhaustion lower than 0.96 M. At this pressure the time of cooling of the thermometer from 15° to 10° was only 177 seconds; while pure hydrogen would have required 288 seconds.

Evidently a new gas of enormous heat-conducting capacity was present, mixed with the last small portion of air. It must have come from the pulverized glass, and probably formed only a small fraction of the mixture. The last cubic centimeter of gas pumped out was collected, and upon subsequent analysis of it, nothing but air was found.

The discovery of the new gas as above outlined, was made nearly a year and a half ago, on March 10th, 1897. On the following day, the pressure had increased to nearly 5 millionths, while the time of cooling of the thermometer, instead of diminishing as usual with increase of pressure, had raised from 177 seconds to 245 seconds, showing that the new gas had largely disappeared. This was subsequently found to be due to absorption by the phosphorus pentoxide used in desiccation.

Long continued moderate heating of the pulverized glass caused the evolution of some air, much carbon dioxide and hydrogen, some carbon monoxide, and more of the new gas. The selective absorption which occurred on cooling, was confined almost wholly to the hydrogen and new gas. After further moderate heating and thorough exhaustion, I raised the temperature, continued the exhaustion, and got the results embodied in the curve *g h*, showing that much of the new gas was present; the conductivity at 0.38 millionth, the last station in the curve, being *twenty-seven times* that of hydrogen. Several days of high heating, with frequent exhaustion, failed to wholly deprive the pulverized glass of its new gas, though the output was greatly diminished. For this and other reasons, I believe that the new gas resides *in* and not simply on the surface of glass.

To make sure that the apparatus was not deceiving me, I sealed off the combustion tube, heated the vacuous parts several hours by means of air- and water-baths as before indicated, admitted air dried over phosphorus pentoxide, exhausted step by step, and got the data for the "small bulb" air curve shown here and in last year's paper. Evidently I had not been deceived about the presence of a new gas in the pulverized glass. I subsequently exposed this lot of glass several days to the atmosphere, spread out in a thin layer. When tested again after this exposure, it yielded the new gas both before and after heating, as freely as at first. This rejuvenation of pulverized glass by exposure to the air, was fully confirmed with another lot made from common window glass; and in connection with the results obtained by the diffusion of air, hereafter described, leaves no room for doubt that the new gas is a constituent of the atmosphere.

Pulverized glass appears to begin evolution of the new gas as soon as the atmospheric pressure is reduced. In one case while making a slow preliminary exhaustion, I tested the air which remained when the pressure was still 132 mm.; and to my great surprise, found it contained not only a trace, but a considerable quantity of new gas. The amount increased rapidly as the pressure was further reduced. This leads to the belief that finely pulverized glass gives up the greater part of its new gas on simple reduction of pressure to a low point, and without

heating ; somewhat as palladium gives up occluded hydrogen.

Several other substances than glass were examined, and nearly all found to contain the new gas. A specimen of old charcoal made from pine-wood sawdust by long exposure to a bright red heat, yielded, as was expected, comparatively large quantities of several gases when heated in vacuum. At some stages of the evolution these were rich in the new gas.

It would seem easy in such cases to remove the diluent gases by oxidation and absorption ; but it is not. After making the necessary additions to my apparatus, I made many attempts of this kind. The reagents used were in large excess on account of the very small quantities of gas treated ; so that some of the observed results may have been due to impurities. Cupric oxide and lead chromate evolved gases of their own almost indefinitely on high heating in vacuum, and then freely absorbed carbon dioxide and moisture at a lower temperature. Soda-lime, dried in vacuum in presence of phosphorus pentoxide, was almost indifferent to carbon dioxide. All the reagents named, especially phosphorus pentoxide, absorbed the new gas ; and all but the latter gave it up on heating.

A specimen of very fine white siliceous sand, when heated in a vacuum, gave a large quantity of gas consisting principally of hydrogen and hydrocarbons, with a considerable amount of the new gas. Some of this mixture was exposed successively to the action of red hot cupric oxide, soda-lime, and phosphorus pentoxide. By this treatment the gases were reduced to less than three per cent. of their former volume. The residue was not very rich in the new gas, because of the absorption of the latter by the soda-lime and phosphorus pentoxide, as I afterwards learned ; but I have shown the curve *o p* of its heat conductivity, because the pressure was carried to a lower point than in any other case. At the last station in the curve, representing a pressure of 0.12 of a millionth, the conductivity was equal to that of 5.1 millionths, or forty-two times as much hydrogen. From this it seems reasonably certain that the curve *e f*, if carried to as low a pressure, would have shown a conductivity at least a hundred times greater than hydrogen. And yet the new gas in that experiment must have been very far from pure on account of the continuous evolution of ordinary gases, as shown by the rise of

pressure and loss of conductivity during the next few hours.

It will be observed that when the new gas was present, the form of the conductivity curves was very different from those of the known gases, the effect of the new gas becoming more prominent as the pressure was reduced. I do not doubt that this was due to the interference of the heavier and slower moving molecules of the ordinary gases always mixed with the new gas. In last year's paper I described the same effect found in a mixture of carbon dioxide and hydrogen. When the new gas is obtained in a state of purity, I expect to find its curve of heat conductivity similar to those of hydrogen and helium, but with immensely increased ordinates.

Believing that the new gas is very much lighter than air or hydrogen, and may therefore be separated from the atmosphere by successive diffusions, I have spent several months in experiments with this end in view. Quite recently my efforts have been crowned with most promising success. The difficulty has been to find a suitable porous septum ; one free from holes, and sufficiently fine grained to prevent more than a very slow passage of air, while a considerable surface is exposed to the atmosphere on one side, and to a fairly good vacuum on the other. Many substances were tried. India-rubber gave encouraging results, but was capricious, and very slow. The best results have been obtained with porous porcelain having its superficial pores nearly closed by suitable treatment. A tube of this kind, closed at one end, and exposing rather more than five square inches of surface to the air, was connected with the apparatus, and the whole kept exhausted to a pressure of one and three-tenths mm. About nineteen cc. of gas were diffused per hour. After thirty-six hours the diffusion tube was shut off, the exhaustion continued, and data for the curve *mn* obtained. It was found impracticable to carry the exhaustion below six millionths, because of the presence of moisture, which interfered with the action of the pump,—no desiccating agent being used. As both phosphorus pentoxide and soda-lime absorb the new gas, they cannot be used for desiccation. If the exhaustion had been carried as far as in the curve *o p*, it is probable that a higher conductivity than in that curve would have been shown ; *i. e.* a conductivity more than forty-two times that of hydrogen, or some-

thing like a hundred times that of air. Here we have the heat conductivity of air at very low pressure, increased something like a hundredfold by one diffusion. I have not yet tried a secondary diffusion, but feel confident that successive diffusions of air will afford a practicable means of obtaining the new gas in a state of approximate purity.

Now let us discover, if possible, the meaning of the extraordinary heat conductivity of the new gas. I have tabulated the molecular weight, density, specific heat, mean molecular velocity, and heat conductivity of hydrogen, helium, carbon monoxide, air, and carbon dioxide, which are the known gases represented in the curve chart. For easy comparison, I have taken not only the density, but the specific heat, mean molecular velocity, and heat conductivity of hydrogen as unity. The similarity of values in the fifth and sixth columns, for molecular velocity and heat conductivity, is striking. On the chart, the curves for carbon monoxide, air, and carbon dioxide, are evidently too high to correspond well with the relative values of molecular velocity in the fifth column; but these curves represent only the last 50 millionths of the complete curves. By following these back to 500 millionths, which is still a rather small pressure, and taking their values at intervals of 10 millionths from no pressure upward, we obtain as a mean of all these values for each gas, the quantities shown in the sixth column. These agree fairly well with the molecular velocities.

Comparison of Gaseous Properties.

1	2	3	4	5	6
Gas	Molecular weight	Density D	Relative specific heat	Relative molecular velocity $\frac{1}{\sqrt{D}}$	Relative heat conductivity
Etherion	? 0.0002	? 0.0001	6000.?	100.?	100.
Hydrogen	2.	1.	1.	1.	1.
Helium	4.	2.	?.300	0.71	0.73
Carbon monoxide	27.8	13.9	0.072	0.27	0.33
Air	28.8	14.4	0.069	0.26	0.32
Carbon dioxide	43.8	21.9	0.064	0.21	0.21

I offer the suggestion that the relatively high conductivity of the last three gases at the low pressure shown in the chart, is due to the dissociation of some of their molecules by unobstructed impact on the walls of the containing vessel, recombination being more and more retarded as the pressure is lessened, because the greater separation of the molecules reduces the frequency of collisions. Helium, perhaps because it is monatomic and therefore incapable of dissociation, has a nearly straight curve like hydrogen; and its ratio, given in the sixth column, varies but little throughout the whole range observed, which was more than 1000 millionths. I have taken the density of helium as 2; but Prof. Ramsay finds it a little less than this when purified as far as possible by repeated diffusions. This makes its relative molecular velocity a little more than 0.71, and brings it still closer to the observed value of its heat conductivity.

From the foregoing, we may reasonably conclude that the heat conductivity of gases at low pressures, and their mean molecular velocities, are closely related. Hence, if we can learn the heat conductivity of an otherwise unknown gas, we can form some idea of its mean molecular velocity; and from this, of its specific heat, density, and molecular weight.

As before indicated, the heat conductivity of the new gas at very low pressure, even when mixed with a large proportion of other gases, is something like 100 times that of hydrogen. I shall not be surprised to find the conductivity of the pure gas 1000 or more times greater than that of hydrogen; but let us be conservative, and for the present purpose call it 100 times, and see what follows. I have given it this value at the head of the sixth column.

If my inference that the heat conductivity and molecular velocity of gases are directly related is correct, then the molecular velocity of the new gas will be 100 times that of hydrogen, as shown at the head of the fifth column. As is well known, the mean molecular velocity of a gas varies directly with the square root of its absolute temperature, and is independent of pressure. The mean molecular velocity of hydrogen at the temperature of melting ice, has been found by calculation to be 5,571 feet per second. Hence the mean molecular velocity of the new gas at the same temperature will be 557,100 feet, or more than 105

miles per second. At anything like this molecular velocity, it would be quite impossible for a gas to remain in the atmosphere, *unless the space above also contained it.* A velocity of only about seven miles per second, if unchecked except by gravitation, would be sufficient to project a body from the earth permanently into space. Even at a temperature very close to absolute zero, the new gas would have sufficient molecular velocity to escape from the atmosphere.

Again, inasmuch as the molecular velocities of gases vary inversely as the square roots of their densities, it follows from our assumption of its molecular velocity, that the density of the new gas is only the 10-thousandth part that of hydrogen, as shown at the head of column 3. This is the 144-thousandth part the density of air. It is generally believed that the gases of the atmosphere distribute themselves in the long run, each as though the others were absent. Hence the new gas must extend 144-thousandth times as high as the heavy constituents of the air, to bring about the same proportionate reduction of pressure, even if gravitation remained constant at all distances from the earth; but the restraining influence of gravitation on the expansion of the atmosphere diminishes as the square of the distance from the earth's center increases. It is evident therefore, without a mathematical demonstration, that the new gas being present in the atmosphere, must extend indefinitely into space without great loss of pressure. This is only another way of stating the result of its assumed molecular velocity. Now there is no doubt that the new gas exists in the atmosphere, though probably in very small proportion; perhaps much less than a millionth. Hence it seems really probable that it not only extends far beyond the atmosphere, but fills all celestial space at a very small pressure. In recognition of this probability, I have provisionally named it aetherion or etherion, meaning "high in the heavens." Its symbol will naturally be Et.

I am aware that strong objections may well be raised to the hypothesis of an interplanetary and interstellar atmosphere; but I can see no escape from the conclusion I have drawn, if I am not mistaken in my premises.

The estimated relative specific heat of etherion appears at the head of the fourth column, based again on the assumed relative

molecular velocity. In estimating the specific heat, I have not made it inversely proportional to the density, as would be required by Dulong and Petit's law, giving a value 10,000 times that of hydrogen ; but have used the formula suggested by Prof. Risteen in his work on "Molecules and the Molecular Theory," which requires that the product of the specific heat and molecular weight of gases shall vary with the number of degrees of freedom of their molecules. I have assumed as probably true, that etherion is monatomic, with atoms possessing only three degrees of freedom.

Of course the values I have estimated for the molecular weight, density, specific heat, and molecular velocity of etherion, are intended only to indicate the *order* of magnitudes we may expect to find on further investigation ; and it must not be forgotten that they are based on two assumptions : first, that the heat conductivity of etherion is 100 times that of hydrogen ; and second, that the ratio of heat conductivity and mean molecular velocity is the same for all gases. As before indicated, I expect to find the heat conductivity of etherion much higher than the value here assigned to it. If so, the real values of its other attributes will be still more startling than those here given. The second assumption, while by no means proven, seems at least a good "first approximation" to the relation between heat conductivity and molecular velocity in gases.

There is some evidence that etherion is a mixture of at least two different gases. In the course of my experiments I have met with a great many specimens, obtained in various ways from various sources; but always mixed with a very large excess of other gases. Some specimens were almost wholly absorbed by the phosphorus pentoxide at first used for desiccation. Others were but partially absorbed, the absorption being very rapid at first, but in an hour or two dwindling to nothing, and leaving a residue of gases permanently showing, by their heat conductivity, the presence of a very considerable amount of etherion. Soda-lime absorbed etherion, but much less freely than phosphorus pentoxide, and gave it up again on heating. The gas thus recovered was but little, if at all affected by phosphorus pentoxide.

In one experiment, the gases evolved from ten ounces of

pulverized window glass, both before and after heating, were passed through coarsely pulverized soda-lime and then over fresh phosphorus pentoxide. Not a trace of etherion remained. The same result was obtained when another lot of the siliceous sand already referred to was used as the source of etherion.

I will venture the conjecture that etherion will be found to consist of a mixture of three or more gases, forming one or more periodic groups of new elements, all very much lighter than hydrogen. If this proves true, I propose to retain the present name for the lightest one.

The transmission of radiant energy through space, has always been to me a fascinating phenomenon, and I have indulged in much speculation concerning the ether—that mysterious something, by means of which it is effected. The remarkable properties assigned to the ether from time to time in order to account for observed phenomena, have excited my keen interest; but I have long entertained the hope that some simpler explanation of the mechanism involved will be found. To me, a less strain of the imagination is required in the assumption that instead of a continuous medium, gaseous molecules of some kind, endowed perhaps with a mode or modes of motion at present unknown to us, are the agent of transmission; a gas so subtle, and existing everywhere in such small quantity, that it has escaped detection.

Perhaps the molecular hypothesis of the ether has proven so attractive to me, because it supports the hope that we may sometime compass the perfect vacuum,—a portion of space devoid of *everything*. Such a vacuum would be opaque to light, and gravitative attraction could not, I believe, act through it. It might afford a new point of view from which to study the profound mystery of gravitation; an *outside* point.

The late De Volson Wood[1] considered the question of a gaseous ether mathematically, and deduced certain necessary properties of the hypothetical gas, chief among which were exceedingly small density, and exceedingly high specific heat. Possibly we are about to find a gas which will fulfil the required conditions. It may be etherion, or its lightest constituent if it turns out to be a mixture. I venture to express the hope that etherion will at least account for some phenomena at present attributed to the ether.

[1] *Phil. Mag., Nov., 1895.*

On account of the presumably extreme smallness of its molecules as compared with those of glass, etherion probably passes through the latter when any considerable difference of pressure exists on opposite sides, though the passage may be very slow. It seems to be condensed or compressed in glass as before indicated, and may evaporate on the side of lower pressure, and be absorbed on the side of higher pressure, after the manner of hydrogen in passing through palladium. In my own experiments, the heat transmission ascribed to the ether may be due to the presence of the new gas inside the bulb. A small fraction of a millionth would be sufficient, and this might escape detection by the pressure-gauge, on account of the necessary compression in the gauge head causing absorption by the glass. Again, etherion must always be present to some extent in all "vacuum tubes" (as well as in my own conduction bulb) on account of its long-continued evolution from glass; and may be the medium of propagation of the Roentgen rays in the vacuum glass and air.

ON THE FACILITIES FOR STANDARDIZING CHEMICAL APPARATUS AFFORDED BY FOREIGN GOVERNMENTS AND OUR OWN.[1]

By Louis A. Fischer.

Received October 17, 1898.

IT is at the invitation of your esteemed president, Dr. C. E. Munroe, that the Office of Standard Weights and Measures submits for your consideration and information this paper, stating what facilities are afforded by foreign governments and our own for the standardization of chemical apparatus. It is but proper that such information should be furnished by this Office; for it, more than any other bureau of the government, is called upon to make the determinations referred to. But before going further, a brief history of the Office will be given, in order that its position and condition may be understood.

The origin of the Office may be said to date from May 29th, 1830, when the Senate passed a resolution calling upon the Secretary of the Treasury to cause to have made a comparison of the weights and measures in use at the principal custom-houses.

[1] Prepared and read before the American Chemical Society, Boston, August, 1898, by direction of Dr. Henry S. Pritchett, Superintendent U. S. Coast and Geodetic Survey, and Standard Weights and Measures.

This task was entrusted to Ferdinand R. Hassler, the then superintendent of the Coast Survey, who discovered large discrepancies among the standards in use. His report led to the establishment of a shop and laboratory, in which copies of those standards adopted by the Department were made and compared. The task was entered upon by Mr. Hassler with his usual foresight and energy; and early in 1836 we find the statement in one of his reports that "forty weights, two pint measures, and four sets of yard standards are ready for final adjustment."

When we consider that the zinc used in the construction of these standards was mined and purified by Mr. Hassler; that machinery and apparatus had to be designed and built; and that the proper working force had to be organized, we cannot help admiring the tremendous energy of the man. So satisfactory were the operations that in June, 1836, Congress passed the following resolution:

"*Resolved*, That the Secretary of the Treasury be, and he hereby is, directed to cause a complete set of all the weights and measures adopted as standards, and now either made or in the progress of manufacture for the use of the several custom-houses, and for other purposes, to be delivered to the Governor of each state in the Union, or such person as he may appoint, for the use of the States, respectively, to the end that a uniform standard of weights and measures may be established throughout the Union."

For the first ten years the entire efforts of the office were devoted to the construction and verification of standards of length, weight, and capacity. These operations required the construction and investigation of comparators, balances, thermometers and barometers; and the determination of the expansion of water and metals, and the solution of other physical problems.

About 1842 the questions of hydrometers and sugars were referred to the Office, then under the direction of Prof. A. D. Bache. The exhaustive report,[1] made in 1848 by Prof. R. S. McCulloh, who had charge of the investigation, has become standard; and the alcoholometric tables now used by the Treas-

[1] Reports from the Secretary of the Treasury of Scientific Investigations in relation to Sugar and Hydrometers, by Professors Bache and McCulloh, 1846; Executive Document No. 50; 30th Congress, 1st session.

ury Department in the collection of duty on spirits differ but slightly from those submitted in the report.

The passage of the law of 1866, legalizing the Metric System, and directing that each state in the Union be supplied with copies of the metric standards, again imposed duties upon the Office which occupied its attention for many years.

In 1891, and again in 1897, the Office was represented on scientific commissions appointed for the purpose of discovering and reporting upon the cause of discrepancies in sugar determinations, by means of the polariscope, at the various ports of entry. As was suspected at the time, much of the trouble was traced to the use of erroneous standards, especially of capacity. Errors were also caused by the use of erroneous values assigned to the quartz control plates by their manufacturers; and, also, by ignoring the effect of temperature on the rotation of the sugar solutions and plates.

As a result of the report of the first commission, the Office was called upon to standardize control plates, and to devise means for rapidly verifying the large number of tubes, weights, and flasks used in sugar laboratories. No apparatus is now used by the Customs Service unless it has first been examined by the Office of Weights and Measures. Nothing illustrates the necessity of having verified apparatus more than the case just cited. In many instances flasks supposed to contain 100 Mohr cc. were found in error as much as one-half cc., and it soon became manifest that if the flasks were to be used without appreciable error they would have to be graduated by the Office. Accordingly, the arrangement here shown[1] was devised for graduating the flasks; and between 2,000 and 3,000 have been graduated during the past six years.

The flasks, samples of which are afterwards tested, must not show a greater error than 0.05 cc.; and no difficulty has been encountered in keeping within this limit. The Office is, therefore, prepared not only to standardize flasks, but also to mark them, provided the interior diameters of the necks do not exceed fifteen mm. or fall below ten mm. There is no reason, however, why this kind of work should be done for the general public, for the same accuracy may also be attained by

[1] For description of device see pages 924 et seq.

manufacturers. No special skill is required to manipulate the device used by us, and a speed of twenty flasks per hour may be maintained without extraordinary effort.

The Office of Standard Weights and Measures is not required by law to make comparisons for other than official purposes ; but inasmuch as we have in our care the national standards, it has been the policy of the Office for years past to endeavor to meet all demands. Our means, however, are very limited, compared with those provided by other governments for bureaus doing similar work. Germany has its 'Physikalisch-Technische Reichsanstalt', where both scientific and technical research are carried on. This institution has two sections, the duties of which are as follows :

SECTION I.

1. The performance of physical investigations and measurements which tend, preeminently, to the solution of physical problems of great scope and importance in a theoretical or practical direction, and which demand a greater outlay of instrumental equipment, consumption of material, or time of observers and computers, than can, as a rule, be offered by private individuals or educational institutions.

2. The solution of matters referred to it by Section II, in so far as the equipment of the latter is insufficient for their accomplishment.

SECTION II.

1. The execution of such physical or physico-technical investigations as are directed by *official authorities* or designed to promote precise machine construction, or other branches of German industry.

2. Verification of measuring apparatus and instruments of control, so far as they do *not* lie in the domain of weights and measures ; the determination of the errors of graduation of such instruments, and the issuance of certificates of results.

3. Construction of instruments and parts of instruments, as well as the execution of other mechanical work for German state institutions and authorities, in so far as their construction by private workshops gives rise to difficulties.

4. In special cases the construction of parts of instruments for

Germans in business, in so far as their construction in private shops necessitates extraordinary means.

In all cases where work is done for individuals or for foreign governments charges are made, designed to cover the cost to the Reichsanstalt. In order to meet the demands there were regularly employed in 1897 seventy-eight persons, many of the scientific attachés being men of international reputation.

The purely weights and measures matters of the Empire are under the control of the Kaiserliche Normal-Aichungs Kommission, with a central office in Berlin, and three branches at Köln, Ilmenau, and Gehlberg, respectively. The commission prescribes rigorous rules and regulations concerning the construction and verification of all forms of measuring apparatus, chemical included, and also defines the tolerance or allowable errors. If the tolerance be not exceeded, and the apparatus otherwise conforms with requirements, it receives the stamp of the commission, and may then be used anywhere in Germany.

Austria, likewise, has its Normal-Aichungs Kommission, with duties and authorities similar to those of its German prototype.

In England the supervision of weights and measures is the work of the Standards Department of the Board of Trade. The verification of every weight and measure is provided for by law, and penalties are prescribed for using apparatus not in conformity with the regulations of the Standards Department.

The inspectors, who in 1897 numbered 1099, are appointed by local authorities, but are required to work under regulations provided by the central office.

In addition to having under its control the standards, which include those of electricity, the office collects information in regard to weights and measures in foreign countries, which is published in its regular reports. Authority is also given to the Board of Trade by law "to conduct all such comparisons, verifications, and other operations with reference to weights and measures, in aid of scientific researches or otherwise, as it may deem expedient."

The Kew Observatory, also, has a standardizing department, and in 1897 about 300 hydrometers, and over 20,000 thermometers, were examined there. Provision is also made for experi-

ments and researches in connection with the work of the various departments of the observatory, and considerable experimental work has been done with platinum thermometers at high temperatures with gratifying results.

Recently a committee was appointed by the British Government "to consider and report upon the desirability of establishing a National Physical Laboratory for the testing and verification of instruments for physical investigation, for the construction and preservation of standards of measurement, and for the systematic determination of physical constants and numerical data useful for scientific and industrial purposes; and to report whether the work of such an institution, if established, could be associated with any testing or standardizing work already performed wholly or in part at public cost." The consideration of this question by the government is due, no doubt, to the demands of scientific investigators, who are at present much inconvenienced by being compelled to resort to Berlin or Paris when the more refined comparisons are required. It is also largely due to the fact that the Reichsanstalt has, by reason of its high standing, done much to assist the German manufacturer in disposing of scientific apparatus.

In France the national standards are in the care of the Conservatoire des Arts et Métiers in Paris, where splendid facilities are provided for the comparison of other standards with them. All trade weights and measures are verified at suboffices, of which there is a large number. While the suboffices are under the control of the Verification Department of the Conservatoire, and while that department is required to verify their standards at regular intervals, it is not required to do their work, but is left free to undertake the more refined comparisons demanded by those engaged in technical and scientific investigations.

Splendidly equipped laboratories for various branches of technology are under the control of the Conservatoire, and these laboratories are at the service of engineers, constructors, and others who desire to use them. The reports of the Conservatoire do not indicate that *special* provisions or regulations are provided for the standardization of chemical apparatus, and the same statement applies to the British institutions. This is no doubt due to the fact that the demand for this character of work is not sufficient to make special facilities necessary.

This brief résumé of the means provided for the standardization of measuring apparatus by the principal governments makes manifest our own deficiencies. It was plainly the intention of Congress, when in 1836, and again in 1866, it directed the distribution of standards to the states, that each state should establish an office where at least the commercial weights and measures could be verified. This is actually the case in but few states, and the Office of Standard Weights and Measures, with an appropriation of less than $8,000,[1] is called upon to standardize county and city weights and measures, and also do other work plainly not that of a national office. The result of this condition of affairs is that the more important investigations and verifications demanded by chemists, physicists, and engineers, are made to suffer. But even if our whole efforts could be devoted to the character of work referred to, our means would be entirely incommensurate with the requirements of a country whose industrial and scientific progress during the last two decades has been, to say the least, extraordinary.

However, this is a matter for Congress to decide; and until that body deems it proper to provide better means, the Office will continue to make the best use of those at hand.

For the benefit of those who desire more detailed information, the following description of our methods and apparatus is given:

WEIGHTS.

Two copies of the "International Kilogramme," both of which are identical in form and material with that prototype, are in the custody of the Office. We have, also, a kilogram balance, constructed by Rueprecht of Vienna, by means of which the relation of two kilograms may be determined within their one hundred millionth part.

For smaller weights we have a set of the best chemical balances on the market; and by making and computing the weighings in the manner indicated in Appendix No. 10, U. S. Coast and Geodetic Survey report for 1892, we are able to secure more than necessary accuracy, say 0.001 of a milligram for a milligram weight. The appendix referred to gives the least square adjustment of the weighings, which are so arranged as to bring

[1] About one-third of this amount is for the electrical department.

a precise result.[1] With the aid of this publication, and with the largest weight of such sets as are commonly used properly determined, any chemist may determine his smaller weights.

While all of those present are aware that weights and other bodies are buoyed up by the air, all do not perhaps, realize, the magnitude of the effect produced. We are led to make this statement by the complaints frequently made by chemists and assayers that the values given by this Office are incorrect. The International Kilogramme is a standard of *mass*, and hence, to express the values of other masses in terms of it, the weighings are referred to *vacuo*. If, therefore, some of the weights of a set are made of brass and some of platinum, the values given are not those that would be found by unreduced weighings made in the air. The difficulty would not be overcome by referring the weighings to air under standard conditions, for if the weights were compared at, say Leadville, at an elevation of 10,000 feet, they would not agree with results obtained at lower altitudes. The difference for 10,000 feet would be, if the weights were platinum and brass, about 3/100 of a milligram per gram, a quantity which a good chemical balance would readily show. Agreement of the *weights* under all conditions would be secured if they were all made of one metal, and, for many reasons, platinum is to be preferred, at least for weights of one gram and less, where the cost of the metal would not be a matter of much consequence.

Some years ago the Office adopted an official stamp, which is placed upon weights meeting the following requirements:

(*a*) Each weight must be made of one piece of metal.

(*b*) The weights, if brass, must not be lacquered, but should be gold-plated or platinized.

(*c*) The finish must be such as to readily show any abrasion, either accidental or otherwise.

VOLUMETRIC DETERMINATION.

No special facilities are required for this kind of work. Furnished with a set of weights, a balance, a thermometer, distilled water, and a table of densities of water, any one may determine his

[1] By this statement is meant that the most reliable results, obtainable from the particular set of observations, are deduced. If the observations are poor the results are correspondingly so.

own apparatus. The reduction to *vacuo* of weighings may be made with sufficient accuracy by assuming that a liter of air weighs one and two-tenths grams at sea-level, and diminishes 0.04 gram for each 1,000 feet of elevation. The density of the weights, if of brass, may be taken as 8.3; if of platinum, as 21.5. This data will certainly satisfy all requirements when dealing with apparatus, the capacity of which is determined by filling or emptying to a mark.

The reduction to *vacuo*, under normal conditions, affects the result by about 0.10 of a per cent., if brass weights be used to weigh the water; and by about 0.11 of a per cent. if platinum weights be used. It is evident that if the result is affected by only 0.01 of a per cent. in changing from one metal to another whose density is two and a half times greater, no appreciable error can possibly be introduced by assuming the densities given above.

Likewise, the assumed weight of air is not subject to variations of more than five per cent., and hence the reduction to vacuo (which, as before stated, affects the final result by about one-tenth of a per cent.), is not affected by more than 0.005 of a per cent. by probable variation in the weight of air adopted. In calibrating specific gravity bottles, and capacity measures provided with ground-glass covers, greater accuracy is, and may be, attained; and an accuracy of one part in 100,000 is not too much to expect, if verified weights and thermometers are used, and if the proper precautions be taken.

In all the work of the Office the capacities are, for convenience, originally found in milliliters, and if the measures are graduated according to some other system the proper factor is used to convert into that system. The liter referred to was defined by The International Committee of Weights and Measures in 1880, in the following language:

"The International Committee of Weights and Measures adopts for its publications and official use the word 'litre' to express the volume of a kilogramme of pure water at its maximum density."

A recently completed determination of the mass of a cubic decimeter of water, made at the International Bureau, confirms what was suspected by the committee when the above definition

was adopted; namely, that the original determination, made a century ago, was in error. The recent results indicate that the liter is larger than the cubic decimeter by one-tenth of a milliliter, or 0.01 of a per cent. This difference may be ignored for most purposes, and the cubic centimeter and milliliter still be considered synonymous terms; but when we adopt a unit of volume we should be careful to distinguish between the two.

THERMOMETRY.

All temperatures are referred to the standard hydrogen thermometer of the International Bureau of Weights and Measures by means of mercurial thermometers made by Tonnelot, of Paris, and compared directly with the hydrogen thermometer. These thermometers give us a continuous range of 80° C.; from —28° to +52°, with a sufficient degree of accuracy to more than satisfy our ordinary needs.

Thermometers submitted for verification are placed between two standards in a trough filled with water, which is thoroughly mixed by propellers operated by the observer, just before the readings are made. Means are provided for rapidly raising and lowering the temperature of the water in the trough, by letting in either cold or hot water, as the case requires. The indications of the thermometers are read by means of a low power microscope, which may readily be moved into position over each instrument. Some idea of the accuracy with which the readings are made, and also of the uniformity in temperature of the water in the trough, may be formed from the statement that after the readings of the two standards have been corrected[1] they do not differ on the average by more than 0.005°, a quantity which cannot be read on any but the most perfect instrument.

Considerable experimental work has been done at the International Bureau with thermometers at temperatures as low as —70° C., and also between +100° and +200°; but, as yet, the work is not complete. As soon as it has been finished the United States will acquire, like other contributing governments, copies

[1] The corrections consist of the calibration corrections for inequality of bore; the correction for errors in graduation of the stem; the zero correction, which depends upon the temperature to which the thermometer has been exposed; the correction for exterior pressure on the bulb, which depends upon the height of the barometer; the correction for internal pressure (if the thermometer be in a vertical position), which depends upon the height of the column of mercury in the stem; and finally, the reduction to the standard hydrogen scale.

of the new thermometers, and our range will then be correspondingly extended. Recent results obtained with the so-called platinum thermometers in England and on the Continent, lead us to hope that this range will soon be much extended. At present, however, the Office is compelled to limit the comparison of thermometers to temperatures between 0° and +50° C., and the following rules will govern the acceptance of thermometers for verification:

(*a*) The stem and bulb must be made of one piece of glass.

(*b*) The graduation must be ruled directly upon the stem.

(*c*) The graduation lines must not exceed in width one-tenth of the space between them.

(*d*) The graduations must not be more than 1° apart.

(*e*) The upper part of the capillary tube must be enlarged; that is, there should be a small chamber in it.

These requirements are essential, even in thermometers of ordinary precision; and until they are fulfilled by our manufacturers, those requiring instruments of superior construction will continue to seek them abroad.

POLARISCOPIC APPARATUS.

Quartz control plates, polariscope tubes, and polariscopes are also examined for sugar chemists, by the Office. Control plates, to be accepted, must be free from imperfections, and must be properly mounted. The values will then be determined by comparison with the standard plate of the Treasury Department. This plate has the value, 99.06° on a scale, the 100° point of which is determined by a solution of pure sugar and water at a temperature of 17.5° C., that contains a mass of 26.048 grams of sugar per 100 milliliters of solution. This solution differs slightly from that used in Germany to determine the 100° point of the Ventzke Scale; but if the samples of sugar be polarized as prescribed by the Treasury Department regulations, and with apparatus tested by the Office of Weights and Measures, the results will agree with those obtained by the German method with German apparatus. If the solutions are made up and polarized at any other temperature than 17.5° C., the effect of temperature must, of course, be considered. The report of the commission of 1897 has not yet been made public, but I under-

stand that the question of bringing our methods, as well as results, into accord with the Germans, was considered.

HYDROMETERS.

Hydrometers, graduated according to various authorities, are used in this country, but no tables of densities corresponding to the graduations have been adopted, except in certain cases by the Treasury Department for its own use. For this reason the table to be used must be designated by those submitting their instruments. The Baumé hydrometers are used, perhaps, more than any others in this country, and the statement made in 1881 by Prof. C. F. Chandler in a report to the National Academy of Sciences is as true now as it was then. His statement was as follows: "Although Baumé described, with great accuracy, the method which he employed to secure the scale for his hydrometers, and it would seem, therefore, as though no difficulty existed to prevent the reproduction of his instruments, nevertheless, it is a fact that among instrument makers the scale has been so modified from time to time that we have the greatest variety of instruments purporting to be Baumé, each one of which has a set of degrees of an entirely different value from that exhibited by any other. I have found twenty-three different scales published by as many different writers for liquids heavier than water, the highest of which gives as the value of 66 Baumé, 1.8922, and the lowest 1.730, no one of which can be said to be correct, or to have been obtained by following Baumé's directions." At the conclusion of this report he offered the following resolution: "*Resolved*, That a committee be appointed to consider what action, if any, is desirable, with a view to establishing a legal value for the degrees of the Baumé and other hydrometers of arbitrary scale, the committee to report at the next meeting." A committee was appointed, but I have been unable to find any report made by it.

It has often been suggested that the only safe plan would be to abandon all arbitrary scales and to use only instruments which record the true densities. This proposition is usually opposed by the so-called practical men; but I see no reason why such instruments should not be used for scientific purposes. We already have in use by the U.S. Coast and Geodetic Survey, and

by the U. S. Fish Commission, hydrometers so graduated, and I have never heard of any complaint from those who are required to use them. What is wanted is the density of sea-water, and the instruments give it directly.

If the apparatus submitted for verification were limited to certain forms, and if the limit of error were in every case stated, the work of the Office would be simplified. We are, therefore, much interested in the movement inaugurated by this society to secure uniformity in the more important measuring apparatus used by chemists, and would be pleased to cooperate with the society in bringing about the desired result. Of course, measuring instruments of all kinds must be designed, primarily, to suit the needs of those who use them, but the uncertainties introduced by having them graduated according to various systems and standardized at various temperatures does not serve any good purpose.

In conclusion, I beg leave to recommend that the following units of measurement be adopted by the society, as they already have been by almost the entire scientific world.

(1) The liter, as defined by the International Committee of Weights and Measures; *viz.*, the volume of the *mass* of a kilogram of pure water at the temperature of maximum density, and under a pressure of 760 mm. of mercury.

(2) Density, defined as the ratio of the mass of a substance to that of an equal volume of pure water at its maximum density (4° C.).

(3) The centigrade degree of the hydrogen thermometer of the International Bureau of Weights and Measures.

I also recommend that some convenient temperature be adopted, at which all volumetric apparatus shall contain their stated capacities.

DESCRIPTION OF DEVICE FOR MARKING FLASKS.

Referring to Fig. 1, *a* is a hollow steel cylinder which fits into the neck of the flask where it is held and centered by the three springs shown in the figure. Its upper end is terminated by a milled head which must be in contact with the top of the flask whenever the device is in use. The diameter of the opening in *a* is such that the rod *b* fits in it without play. *b* and *c* are round rods

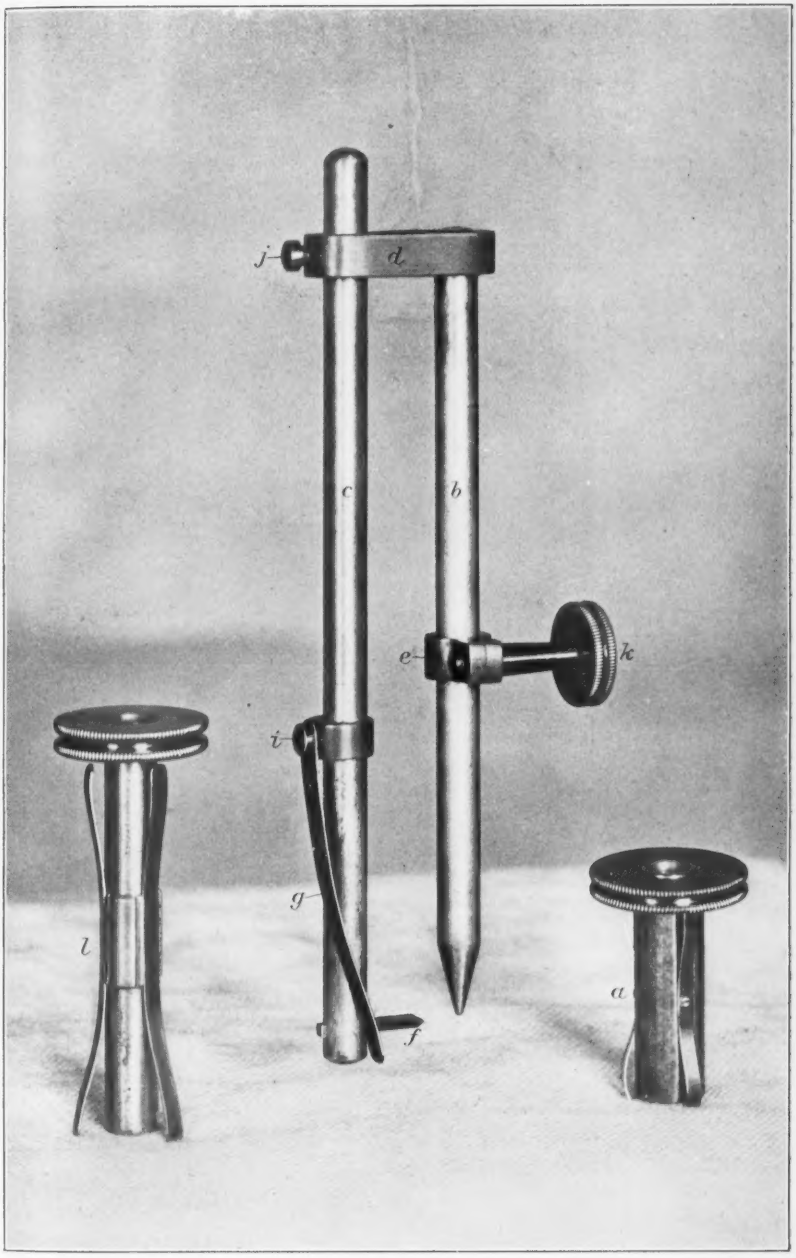


Fig. 1.

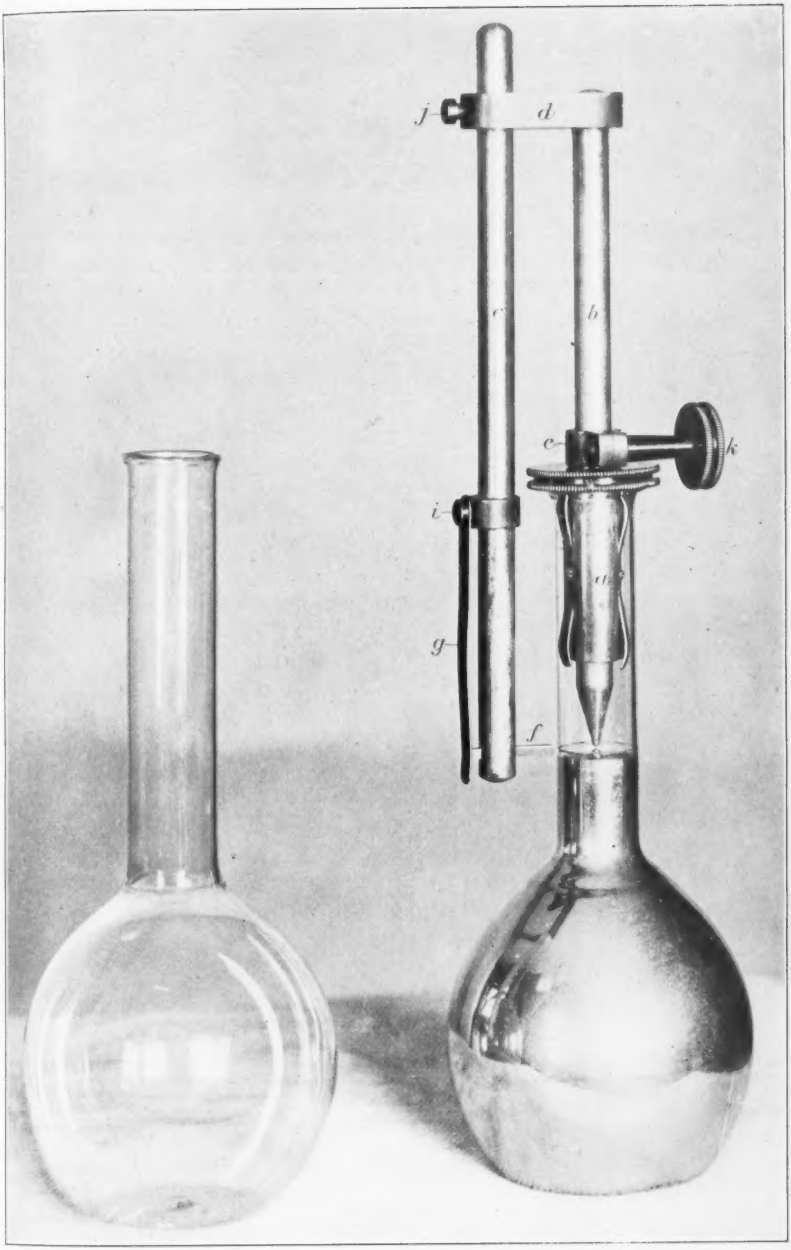


Fig. 2.

made of Stubbs' steel, parallel to one another and rigidly connected by *d*. The cutter *f* is made of square steel, and while it must slide freely back and forth in the opening provided for it in *c* it must not have appreciable side play. By means of the screw *j* which clamps *c* to *d* the height of the cutter must be adjusted so that the edge of the cutter operates in the horizontal plane tangent to the pointed end of *b*. The clamp *e* forms a stop on *b* and may be clamped at any point by the screw *k*. The spring *g* is swivelled at *i* and its function is to press the cutter towards *b*. *l* is an extra bearing for flasks having necks of smaller diameter than could accommodate *a*.

The operation of marking is illustrated in Fig. 2. The flask on the right represents a standard, which is essential as the device is only designed to reproduce the volume of some flask assumed to be correct. The standard is represented filled with mercury up to the point where it is tangent to the lower end of *b*. The order of operation is as follows: The bearing *a* or *l* as the case requires is pushed into the neck of the empty *standard* until the milled head comes in contact with the top of the flask. Then the rod *b* of the device is put in the bearing and pushed down until the cutter falls into the mark on the neck of the flask. The clamp *e*, which should always be kept in contact with the upper end of the bearing, is then clamped. The device may now be rotated in the bearing and if this be done the cutter will follow the mark on the neck. The whole arrangement is now removed from the neck of the standard and clean mercury is poured in until it fills the flask to the mark. This may be determined by putting the arrangement back in its original position in the standard and if the mercury is tangent to the lower end of *b* we have in the proper quantity. This is not, however, an easy matter to accomplish, but sometimes requires a little skill and patience. If the clamp *e* has not been disturbed the cutter will still travel in the mark when the mercury has been adjusted to tangency. Having secured the proper quantity of mercury the whole arrangement is again removed from the neck of the standard, and the mercury is poured into the flask to be graduated. Usually there will be a number of air bubbles in the second flask which must be removed before we attempt to mark it. Having removed the air bubbles, which must be done without raising

the temperature greatly, the bearing is placed in the neck of the flask and the point of *b* is adjusted to tangency by means of the stop *e*. The neck of the flask in the vicinity of the cutter is then covered with paraffin by means of a camel's hair brush which is kept for the purpose in a dish of melted paraffin. The paraffin will cool almost instantly, and as soon as it does the spring *g*, which has heretofore been to one side of the cutter, is now adjusted to press the cutter against the paraffined flask. The arrangement is then rotated in the bearing and the cutter removes the paraffin in its course and exposes the glass. After a couple of revolutions the spring is pushed to one side, the cutter pulled back, and the whole arrangement removed from the neck of the flask which is now ready for etching. The mercury may be poured back into the standard in order to test whether its volume has changed by reason of the handling it has received. Usually such tests will show an increase in the volume of mercury, which must again be adjusted before it is used to mark another flask. If, however, we have a number of flasks to graduate, the volume of the mercury will be found quite constant after the first half-dozen have been marked, due to the fact that it finally acquires a fixed temperature, which is determined by the amount of handling it receives and the temperature of the room. After this state is reached, ten or a dozen flasks may be marked without the volume of the mercury being appreciably changed. The etching is done by applying hydrofluoric acid to the cut in the paraffin by means of a small camel's hair brush. The flask is then set aside for about ten minutes, when the acid is washed off with water. Finally the neck is heated over a Bunsen burner and the paraffin is wiped off with a cloth.

The arrangement here described was devised for the special purpose of marking the 100 cc. flasks used by the United States Treasury Department. The interior diameter of the cylindrical portion of these flasks (the necks) is approximately thirteen mm. Any variation of this diameter from that of the standard flask introduces an error in the capacity of the marked flask, due to the fact that the height of the meniscus of the mercury depends, within certain limits, upon the diameter of the tube containing it. It is therefore important that a standard be provided for

each form of flask to be marked. This may always be readily accomplished by placing a temporary mark on any flask and then determining the capacity to this mark. With this and the interior diameter of the neck of the flask known we may compute where the mark should be placed to give the correct capacity. When this point has been determined a permanent mark may be made with the device by adjusting the cutter to travel across this point.

The use of this method of marking flasks is restricted on account of the pressure exerted by the mercury on the walls of the flasks, which is sometimes sufficient to cause them to break. This does not occur often with 100 cc. flasks, but it is doubtful whether ordinary flasks of greater capacity than 500 cc. would sustain the pressure with safety.

THE CYCLICAL LAW OF THE ELEMENTS.[1]

By Thomas Bayley.

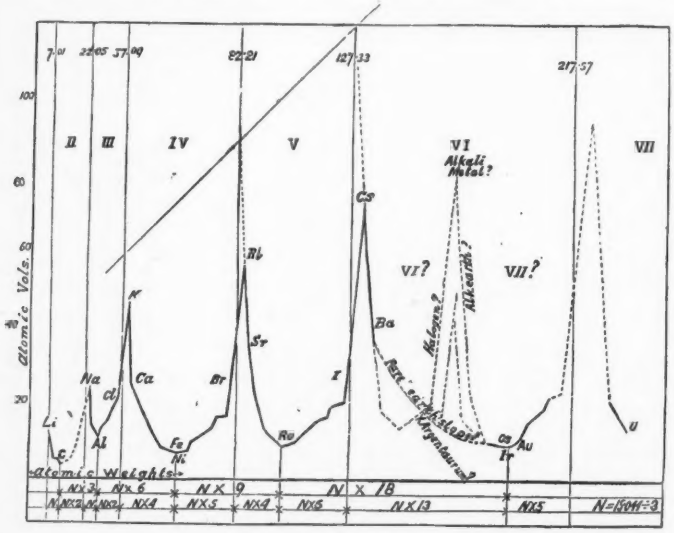
Received September 7, 1898.

WHEN the elements are arranged in a line in the order of their atomic weights, it is apparent that there is from lithium to fluorine an orderly transition from the intensely positive alkali-metal type to the intensely negative halogen type, and then a sudden reappearance of the positive type in sodium, after which there is a second orderly transition to the negative type (chlorine), and then another change to positivity (potassium). Up to this point, therefore, two complete cyclical changes have been established, the first cycle from lithium to sodium—in all its essential details—being analogous with the second from sodium to potassium. If then we proceed with the lineal arrangement, it is clear that we must first of all look for transitions and for reappearances of the alkali-metal type; in other words, for the continued development of the cyclical arrangement. And since analogous but modified transitions actually recur, and halogens followed by alkali metals reappear, it is evident that the law of progression is actually cyclical. The first and fundamental feature of atomic progression is a progression in cycles.[2] The lithium-sodium cycle is a cycle involving the seven elements, lithium, beryllium, boron, carbon, nitrogen, oxygen, and fluorine,

[1] Reprinted from *Chemical News*, April 7, 1898.

[2] Bayley: *Phil. Mag.*, January, *1882*.

and the sodium-potassium cycle involves also seven elements; and for this reason, and because in the succeeding cycles analogous groups of seven elements are repeated, almost all tabular expressions of the atomic progression have been set in a septenary form. But these arrangements, by unduly emphasizing the septenary character of the periodic change, have perhaps somewhat obscured the more important and fundamental cyclical features of the progression. Before attempting to substantiate this assertion, however, it is necessary to consider the nature of the higher cycles which are complex, and to show that the properties of any element are more profoundly modified by position in the cycle than by position in the septenary series.



Assuming that hydrogen is the first element of an incompletely known cycle which we may call the first, then the lithium-sodium cycle becomes the second and the sodium-potassium cycle becomes the third. Beyond this point the cycles are complex, and the fourth contains seventeen elements, of which the first, potassium, is completely analogous with sodium; the second element, calcium, with magnesium; and the third, scandium, with aluminum; for sodium and potassium both conform

to the alkali metal type, calcium and magnesium to the alkaline earth metal type, and aluminum and scandium to the type of the earth metals; but the analogies between silicon and titanium, and between phosphorus and vanadium, are less perfect, while the analogies between oxygen and chromium and between chlorine and manganese are very much less pronounced. The analogies between the latter pairs, indeed, appear to consist chiefly in structural resemblances between the compounds of the respective elements, due to the valency or atomicity impressed upon the septenary series as a primary law of its formation. The analogies between the elements of the septenary series entirely constituting the second and third simple cycles, and the elements constituting the first portion of the fourth cycle, a compound cycle, are perfect therefore only in the first, second, and third elements of each series respectively, and become fainter in the later members. Now the elements between which complete analogy exists are those which have analogous positions in the cycle, and the elements between which incomplete analogy exists are those which have not analogous cyclic position, but merely analogous serial position. The region of the third cycle —occupied by sodium, magnesium, and aluminum—corresponds to the region occupied by potassium, calcium, and scandium in in the fourth cycle for each group of elements occupies the front portion of its cycle, whereas silicon, phosphorus, and sulphur in the third cycle occupy a region posterior to the point of lowest atomic volume, while titanium, vanadium, and chromium occupy a region anterior to the point of lowest atomic volume in the fourth. Neglecting for the moment the position and properties of the three intermediate elements, iron, nickel, and cobalt, and passing to the consideration of the second septenary series, which completes the fourth cycle, and to comparison of this with the third cycle, we see that analogy fails, or is chiefly structural, between copper and sodium, between zinc and magnesium, between gallium and aluminum, but becomes more pronounced between selenium and sulphur, and perfect between bromine and chlorine. The structurally analogous copper and sodium have nothing in common except serial position, and the fully analogous bromine and chlorine have similar cyclic position; chlorine fails to find a complete analogue in manganese which has not analogous

regional position, but finds it in bromine, because both occur at the end of the cycle. To make this clearer it is necessary to study more closely the architecture of the simple and complex cycles. The increment of atomic weight occupied by the series lithium-sodium is 15.98; the increment from sodium to potassium is 16.05; the increment from potassium to iron is 16.86; the increment from copper to rubidium is 22; the increment from rubidium to ruthenium is 16.2; and the increment from silver to cesium is 25.04. The increments for the series constituting the simple cycles, and for the series occurring in the first portions of the fourth and fifth cycles, is, therefore, about 16 (or 17), and the increment for the series occurring in the posterior halves of the fourth and fifth cycles is 22 and 25. If we proceed to consider the nature of the sixth cycle, we are met at the outset by a difficulty, for since no alkali metal of higher atomic weight than cesium has yet been discovered, it is not easy to fix the upper limit of the cycle.

The usual arrangement of the elements in odd and even series, such as Mendeléeff's original classification or Brauner's modification of it, show three septenary series and an intermediate group between cesium and osmium, and the increment of 57 in atomic weight corresponding to this space is just about what would be required for twenty-four elements. Commencing with potassium and writing its higher analogues in a line, we obtain the sequence potassium, copper, rubidium, silver, cesium, in which each alkali metal is followed by a subfamily analogue, and, unless other conditions intervene in the sixth cycle, the unknown element of atomic weight c. 156 should be an analogue of copper and silver, and the unknown element of atomic weight c. 170 should be an alkali metal and the first member of a seventh cycle. But as every alkali metal is preceded by a halogen (neglecting the argon family), and succeeded by an alkaline earth metal, it also follows that the element of atomic weight 170 should be similarly accompanied. Reasoning also from analogy, we must suppose that the unknown halogen is somewhat less negative than iodine, because negativity decreases with atomic weight in the halogen family, and the unknown alkali metal and the alkaline earth metal must be more positive than cesium and barium, respectively, because positivity increases with atomic

weight in the highly positive families. It also seems necessary, from analogy, to assume the existence of an intermediate group between 152 and 154, but in all other instances, both lower and higher, in the atomic progression the intermediate groups are preceded not by basic earth metals (such as samarium), but by elements such as chromium and manganese, molybdenum and (—c. 100), and tantalum and tungsten, which form oxides of a pronounced acidic character. If, therefore, there is a cycle stretching from cesium to the position of atomic weight 170, it must differ essentially from compound cycles below it and the compound cycle above it. We may now profitably turn to a consideration of the curves of atomic volume in the various cycles. It was first pointed out by L. Meyer that atomic volume has a periodic variation, and the curves given in the accompanying figure are essentially identical with those drawn in his "Modern Theories of Chemistry."

It is evident that atomic volume is a cyclical function. Each cycle, simple or compound, shows a loop, and all truly analogous elements occupy similar positions on the curves. The alkali metals have high atomic volumes, and occupy the top of the curves; the alkaline earth metals invariably occur on the downward flanks. The earth metals occur lower down on the same flank, and in the fourth and fifth angles they immediately precede the elements (titanium, vanadium, chromium, manganese), (zirconium, niobium, molybdenum,—), which form acidic oxides. The intermediate groups occupy the troughs of the curves, and the series copper-bromine, silver-iodine, gold-bismuth occur on the rising posterior portion of the curves. If, then, the element of atomic weight c. 170 is an alkali metal, it is reasonable to conclude that it has a high atomic volume and that curve of atomic volume indicated by the upper dotted line must exist, even if it does not follow—however probable it may appear—that this curve need necessarily be as steep as it is drawn. The curves of atomic volume present very remarkable regularities, using the word curve to mean the collection of straight lines drawn from point to point. Thus the lines drawn from chlorine to potassium, from bromine to ruthenium, and from iodine to cesium, are almost exactly parallel, as are some other lines of similar character.

In the earlier diagrams, before the atomic volume of cesium was determined, the line from iodine to cesium was assumed to occupy a position in accordance with this parallelism, and the facts when determined justified the assumption, and for these reasons it seems permissible to use this method of drawing parallel lines as a means of forecasting the atomic volumes of elements as yet undiscovered. Now, whether we draw the upper or the lower dotted curve, in which latter case the metal (atomic weight c. 170) would not be a perfect analogue of sodium and potassium, it appears necessary to believe in the existence of a halogen and an alkaline earth metal, and also of a group of intermediate elements of the iron or platinoid type, followed by a series commencing with a true analogue of copper and silver. It is a significant fact that, although a number of elements are assigned to positions between atomic weight 150 and the atomic weights of tantalum and tungsten, there has as yet been described no element corresponding to the hypothetical intermediate group, or to the supposed halogen, alkali metal, or alkaline earth metal. On the other hand, the numerous elements between atomic weight 150 and tantalum which have been described are elements of a purely earth-forming type, separable from well-located earths, such as scandium, yttrium, and lanthanum, which they closely resemble, only by repeated fractional precipitations or similar methods. So far research has not rendered it possible to assign definite atomic weights to the majority of these rare earth metals, and much of the brilliant laborious work done upon them by Crookes and others has tended rather to bewilderment, yttrium and samarium, and several other rare earth metals, having been shown to be complex bodies; but accepting the usual location of these metals provisionally, it would seem that Tb>Er>Tm>Yb fall just where the hypothetical alkali metal of atomic weight c. 170 would require to be placed, and that with these four elements there is a regular but small progression from greater to less basicity in the order given, which is what we might expect if the sixth cycle stretches from cesium to about atomic weight 233 with a long flank on the anterior (descending) portion of its curve of atomic volume occupied by a series of rare earth metals. This conception of the cyclic progression eliminates the unsym-

metrical dotted curve, and substitutes a cycle of approximately symmetrical dimensions. The cyclical increments then appear as

Cycle II.	Cycle III.	Cycle IV.	Cycle V.	Cycle VI.
c. 16	c. 16	46(3 × 16)	47(3 × 16)	94(6 × 16)

and the position of lowest atomic volume, which in the lower cycles occurs near the middle of the curve, occupies in the sixth cycle a position nearer to the end. In these measurements of the length of the cycles, we have taken the increments of atomic weight from one alkali metal to the next higher in progression, but it does not necessarily follow that this is the proper method. For if the elements have been produced, as was suggested by Sir William Crookes, during the cooling of some primal form of matter—the protyle—we may imagine that after the genesis of each cycle had been completed, and the halogen had been formed, there came a turning-point in the evolution, probably marked by the development of an element of the argon type, after which the course of atomic genesis again set in the direction of alkali-metal formation. If so, then clearly the cycle commenced at this turning-point, but the first element of the new series may not have been formed immediately. The conditions at the commencement of the cycle may not have permitted of the coherence of the newly condensed material into the atomic form, and the first element of the new cycle may, as it were, have had to wait until the attractive force of the condensed protyle had time to gather. Some such conception might explain a lateness in the appearance of an element like argon, endowed with little or no affinity ; for if the element were all the while forming in a kind of nebulous intermediate condition, and if, as it appears, atomic weight is a function chiefly or wholly of the temperature at the moment of atomic formation, such an element might not take the atomic form until after the commencement of the next cycle. This, however, assumes some sort of connection between the attraction of the primal molecules for each other and the chemical affinity of the completed atom. Before we can attempt to fix the true dimensions of the cycles in accordance with this hypothesis, we must cast about for evidences of definite arithmetical dimensions in other regions of the cycles than the beginnings. The point of lowest atomic volume seems to be another definite turning-point in the cyclic

changes; and taking carbon as representing this point in the second cycle, and iridium the similar point in the (large) sixth, we get an interval of atomic weight of 180.5. Dividing this by 12 we obtain 15.04, and adding this number to the atomic weight of carbon (11.97) the sum is 27.01, the atomic weight of aluminum (27.02), the element of lowest atomic volume in this cycle. By adding to aluminum (27.01) the expression 15.04×2, we obtain 57.09, which is between iron (55.9) and nickel (58.6) and the addition of 15.04×2 again gives 102.24, which is very near the atomic weight of ruthenium (102.7); and adding 15.04×6 to 102.24 gives 192.48, which is the atomic weight of iridium. Now assuming this dimension 15.04 to represent the true dimension of a simple cycle, and adding it to lithium, we have $7.01 + 15.04 = 22.05$, between fluorine and sodium, as the initial or turning-point for Cycle III. In like manner, $22.05 + 15.04$ gives 37.09, between chlorine and potassium, as the initial-point of Cycle IV; $37.09 + 15.04 \times 3$ gives 82.21 between bromine and rubidium, for the corresponding point of the fourth cycle, and $82.21 + 15.04 \times 3$ gives 127.33, between iodine and cesium for the sixth cycle. If the sixth cycle is a large cycle $127.33 + 15.04 \times 6$ indicates 217.57 as its probable terminating point. If the cyclic dimensions be fixed in this manner, the point of lowest atomic volume in the various cycles occurs in the second or third at the one-third distance, and in the fourth and fifth at the four-ninths distance from the initial point of the cycles. Thus:

Li $7.01 + \frac{15.04}{3} = 12.01$ (C = 11.97),

$22.05 + \frac{15.04}{3} = 27.02$ (Al = 27.01),

$37.09 + \frac{15.04}{3} \times 4 = 57.13$ (Fe = 55.9; Ni = 58.6),

$82.21 + \frac{15.04}{3} \times 4 = 102.25$ (Ru = 102.7),

$127.33 + \frac{15.04}{3} \times 13 = 192.46$ (Ir = 192.5).

It may be assumed that the actual turning-point of lowest atomic volume may not be occupied by an element having the atomic weight corresponding to the temperature existing when the evolutionary crisis arrived.

ATOMIC VOLUME AS A PERIODIC FUNCTION.

By Thomas Bayley.

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IN a communication to the *Chemical News* (April 7, 1898),[1] the author showed that between each halogen and the next succeeding alkali metal there is a point of atomic weight that may be assumed to indicate the commencement of a cycle. This point, on the hypothesis of atomic condensation from cooling protyle, marks the temperature, expressed in terms of atomic weight, at which the tide of evolution turned and the conditions began again to necessitate the appearance of the positive atoms inaugurating a new cycle. It was shown that if the size of the cycles be reckoned from the "critical" points, the measurements are regular, and that each cycle corresponds exactly to an increment of atomic weight equal to $15.044 \times x$, x being one of the integers[2] 1, 1; 3, 3; 6, 6, taken consecutively. The apparent irregularity in the cyclic dimensions thus disappears, but the sequence of the individual elements remains unchanged and the increments of atomic weight between each atom and its next neighbor still appear to be quite irregular. But in saying that the elements occur irregularly, we merely assert that they do not appear at equal intervals, and the absence of this empirical regularity does not imply the absence of law. The study of atomic volume, on the contrary, discloses some interesting relations between the elements and suggests a definite influence ruling their occurrence. The atomic volume of an element is the result of the action of one of the fundamental forces with which the atom is endowed; this force is the attraction of cohesion between atoms of like kind. Atomic volume is thus a very important property of the elements, and if any general relations exist between atomic volumes it is desirable that they should be shown. The accompanying chart of atomic volume has been prepared and abscissae have been drawn through the "critical" points, marking the cyclic boundaries. These "critical lines" are, for the sake of easy reference, marked with letters, the lines through atomic weight 7.01 being called A; the line through atomic weight 22.05, B; through 37.09, C; through 82.21, D;

[1] See the preceding paper.

[2] The series 1, 3, 6, ..., is such that each term is made up of the sums of the natural numbers 1, 2, 3, 4, 5, 6, etc.

through 127.33, E; through 217.57, F; and the line through 307.83, G. Points corresponding to atomic volumes 30, 60, 90, 120, 150, etc., have been marked off on the line A, and lines parallel to the ordinate have been drawn through these points cutting the critical lines at right angles. The "critical intersections" of these horizontal lines with the critical lines are referred to as A_{30}, B_{30}, C_{30}, D_{30}, etc. It is possible to draw through various critical intersections a series of straight lines, each of which passes also through the points of atomic volume of two elements on the chart. The lines that can be so drawn are given below under the heading I. It will be seen that they are "analogous lines," that is, they pass through atom analogues in every instance. The coincidences of lines and points although not mathematically exact are very close approximations, even when the scale of the chart is so large as one-tenth inch per unit of atomic weight and atomic volume. This is a notable fact when one considers that the determinations of density have been made at different temperatures, and compared with water at different temperatures, and that even if the determinations had been made at a standard temperature this would still have lain at varying distances from their respective melting-points, and that a certain influence upon atomic volume must be credited to the forces of crystallization, to allotropy, etc. In addition to the lines through the "critical intersections" a large number of analogous lines can be drawn through *three* elements. These are given under the second heading (II). In a number of instances the lines cross in an element, thus locating it both as regards atomic weight and atomic volume; and by following out the system of analogous lines it is possible to tentatively assign atomic volume where this is not known, as has been done with scandium (atomic weight 44), yttrium (atomic weight 89.6), and fluorine, and furthermore to tentatively fix both the atomic weight and atomic volume of unknown elements, such as eka-tellurium (atomic weight $c212$), VII^{I}, VII^{II}, VII^{III}, etc. It has proved possible to construct a portion of an assumed eight cycle of dimensions 15.044×6, although elements of so high atomic weight have never been discovered, and to locate elements along the "rare earth slope" in cycle VI. It is not necessary, however, either to assert or deny the

actual existence of elements having the positives thus assigned, although some of them, such as eka-tellurium, VII^{I}, VII^{II}, VII^{III}, all of lower atomic weight than thorium, probably occur somewhere in nature. It is enough to recognize a general relationship between the elements, as revealed in a geometrical form by the particular method herein described. Of the elements on the "rare earth slope" it may be said that if they should be found to occur as they are placed they would be in lineal analogy with the known elements, and that although it will probably ultimately be possible to classify them in the usual groups their properties will be found to be so greatly dominated by their position in the earth region of cycle VI that the structural resemblance between their compounds and the compounds of their analogues in the lower cycles will be obscure.

The atomic volumes of hydrogen, nitrogen, and oxygen have been published while this investigation was in progress, and these elements have been found to fall into the system of lines. The accompanying table shows the atomic weights and atomic volumes which have been used in setting out the chart.

The existence of a series of points positionally interrelated by lines such as those here described appears to be of mathematical interest independently of reference to any special chemical significance.

I.

THROUGH AN INTERSECTION AND TWO ELEMENTS.

	Intersection.	Group I.	Group II.	Group III.	Group IV.
	B_{30}	Na	Mg		
	C_{90}	K	Ca		
	D_{90}	Rb	Sr		
	E_{120}	Cs	Ba	La	
	F_{120}	VII^{I}(223.7)	VII^{II}(228.2)	VII^{III}(230.8.)	Th
	G_{120}	$VIII^{I}$( )	$VIII^{II}$( )	$VIII^{III}$( )	$VIII^{IV}$
	E_{60}	Li	Ca		
	G_{60}	Na	Ca		
	F_{30}	K	Ba		
Same line	A_{60}	Rb	VII^{II}		
Same line	A_{60}	Rb	$VIII^{II}$		
	F_{180}	Cu	Sr		
	D_{30}	VII^{I}	Be		
	G_{150}	VII^{I}	(154.5^{II})		
	B_{60}	(151.7^{I})	(154.5^{II})		
Same line	C_{210}	Cs	(179.3^{II})		
Same line	C_{210}	(169.4^{I})	(179.3^{II})		

Intersection.	Group I.	Group II.	Group III.	Group IV.
C_{150}	Cs	Hg		
G_{60}	H	VII^{II}		
A_{30}	(169.4^{I})	Hg		
E_{30}	Cr(291.1)	Sr		

In addition to those above:

	Intersection.	Group II.	Group III.	Group IV.
	B_{60}	Ca	Sc	
	D_{60}	Sr	Yt	Zr
Same line	E_{30}	Mg	Sc	
Same line	E_{30}	Mg	Yt	
	D_{30}	Be	Sc	
	A_{30}	Ca	In	
	F_{90}	Zn	Ga	
	F_{150}	Cd	In	
Same line	G_{30}	(154.5^{II})	(159.4^{III})	
Same line	G_{30}	(154.5^{II})	Al	
	A_{30}	(171.3^{II})	(173.7^{III})	
	D_{30}	Hg	(159.4^{III})	
	G_{150}	VII^{II}	Tl	

In addition to the above:

Intersection.	Group III.	Group IV.
A_{60}	Sc	Ti
C_{120}	La	Ce
C_{210}	(173.7^{III})	(175.6^{IV})
G_{60}	Al	Zr
G_{30}	B	(161.3^{IV})
B_{90}	(159.4^{III})	(175.6^{IV})
B_{30}	Yt	(161.3^{IV})
G_{30}	(173.7^{III})	Th
F_{30}	VII^{III}	$VIII^{IV}$
B_{30}	La	Pb
F_{90}	Ga	Ge
G_{60}	Tl	Pb

Intersection.	Group V.	Group VI.
A_{60}	V	Cr
C_{90}	Nb	Mo
B_{60}	pr Di	W
D_{120}	(166^{V})	(167^{VI})
C_{240}	VII^{V}	U
C_{90}	pr Di	ne Di
B_{30}	Sb	W
B_{30}	Nb	Mo
D_{30}	VII^{V}	(212^{VI})
G_{30}	(166^{V})	(212^{VI})

Intersection.	Group V.	Group VI.
F_{30}	V	pr Di
C_{60}	Ta	(167^{VI})
A_{120}	Ta	W

Intersection.	Group II.	Group VI.
E_{120}	Ca	S
E_{120}	Sr	Se
B_{60}	Sr	Te
B_{60}	Ba	(212^{VI})
B_{60}	(154.5^{II})	(167^{VI})
D_{150}	Ba	ne Di
B_{30}	Ca	Mo
B_{210}	Sr	Mo
G_{180}	VII^{II}	(212^{VI})
E_{30}	Sr	(212^{VI})
C_{60}	$(154.5)^{II}$	W
F_{150}	Ba	Te
G_{90}	VII^{II}	(167^{VI})
G_{30}	Mg	O
G_{30}	Cd	Cr
F_{30}	Zn	Cr

Intersection.	Group VII.	Group IV.
A_{30}	F?	Ti
A_{30}	Cl	Sn
A_{30}	Br	Ce
A_{30}	(147.5^{VII})	Pb
A_{60}	(214.8^{VII})	Th
C_{30}	I	Th
G_{30}	(214.8^{VII})	Ti
B_{30}	Br	(161.3^{IV})

Intersection.	Group IV.	Group VII.
G_0	Sn	F?
G_0	Zr	Cl
F_{30}	Sn	Mn (approx.)
G_{60}	Sn	(99.9^{VII})
A_{30}	Zr	(168.8^{VII})
Same line G_{30}	Th	(168.8^{VII})
Same line G_{30}	Pb	(168.8^{VII})
B_{60}	(161.3^{IV})	(186.7^{VII})

Intersection.	Group I.	Group I.
F_{120}	H	Rb
A_{30}	Na	Cu
A_{60}	Cs	VII^{I}
B_{90}	Rb	(151.7^{I})
C_{210}	Cs	(169.4^{I})
D_{90}	K	Li
G_{180}	Rb	Li
C_{90}	VII^{I}	$VIII^{I}$

Intersection.	Intersection.	Group I.
D_{180}	C_{60}	Na
G_{90}	E_{60}	K
A_{240}	B_{150}	K
C_{120}	D_{60}	Rb
C_{150}	D_{60}	Ag
G_{210}	E_{60}	Cu
C_{60}	G_{90}	Cs
A_{240}	E_{150}	VII^{I}
A_{180}	C_{150}	(169.4^{I})
B_{150}	D_{90}	(151.7^{I})
B_{60}	E_{30}	Au
G_0F_{60}	E_{120} (D_{150}) (C_{180})	Cr
A_{150}	E_{120}	$VIII^{I}$

II.

THROUGH THREE ELEMENTS.

G roup I.	Group III.	Group I.
Li	Al	Cu
H	Ga	Ag
Cu	Tl	Ag
Ag	Al	Au
Li	Ga	$Cr(291.1^{I})$
(151.7^{I})	Tl	Cr
(151.7^{I})	La	(169.4^{I}) (approx.)
Li	In	(169.4^{I})

NOTE.—In this group of lines Li is the only element of Group I having alkali-metal properties, the other elements of Group I being, for the most part, members of the subfamily.

	Group I.	Group II.	Group II.
	H	Mg	Cd
	Li	(171.3^{II})	Hg
	Rb	Ca	Be
Same line approx.	Na	Ca	Ba
	Na	Ca	VII^{II}
	K	Sr	(154.5^{II})
	Rb	VII^{II}	$VIII^{II}$
	$VIII^{I}$	Ba	Mg
	Cu	(154.5^{II})	$VIII^{II}$
	Cr	Cd	Mg
	Au	(154.5^{II})	Sr
	(151.7^{I})	Zn	$VIII^{II}$
Same line	(169.4^{I})	Cd	Zn
	(169.4^{I})	Cd	Be
	(169.4^{I})	Zn	Be
	(169.4^{I})	Ca	Hg (approx.)

	Group I.	Group V.	Group II.
	H	P (amorph.)	(171.3^{II})
	Li	P	$VIII^{II}$
	Cu	V	Mg
	Li	Nb	Hg
	Li	Sb	(154.5^{II})
	Na	Sb	(171.3^{II})
Same line[1]	K	(166^{V})	(154.5^{II})
	K	pr Di	Sr
	K	pr Di	(154.5^{II})
	K	(166^{V})	Sr
Same line[1]	Au	(166^{V})	Sr
	Au	pr Di	Sr
	Au	Sb	Ca
	Ag	Nb	Ca
	Au	As	Mg
	Au	VII^{V}	$VIII^{II}$
	Cr	Nb	Mg
	Cr	Bi	Sr
	(151.7^{I})	P	Mg

	Group II.	Group III.	Group III.
	Mg	Sc	Yt
Same line	Sr	Sc	Al
	Sr	Al	B
	Sr	Sc	B
	Cd	Ga	Al
	Mg	La	VII^{III}
Nearly coincident	Be	(159.4^{III})	$VIII^{III}$
	(154.5^{II})	(159.4^{III})	$VIII^{III}$
	Cd	(159.4^{III})	VII^{III}
	Be	Ga	VII^{III}
	Sr	La	(173.7^{III})
Same line	Hg	(173.7^{III})	Al
	Hg	(173.7^{III})	Ga
	Hg	Ga	Al
	Cd	Ga	Al
	Cd	Al	(173.7^{III})
	(171.3^{II})	(173.7^{III})	Yt
	Hg	La	(159.4^{III})
	Ca	Yt	La
	VII^{II}	In	La
	Zn	In	VII^{III}
	Be	In	$VIII^{III}$

[1] This line passes through K, Sr, I, pr Di (154.5^{II}), (166^{V}), Au, and forms several combinations besides these four; *e. g.*, K, Sr, (154.5^{II}); K, I, Au; Au 154.5, Sr; Au (166^{V}), pr Di, etc. Several similar lines exist.

Group II.	Group III.	Group III.
$VIII^{II}$	La	Al
$VIII^{II}$	VII^{III}	(159.4^{III})
(154.5^{II})	In	B
(171.3^{II})	Ga	Al

Group IV.	Group V.	Group III.
Ti	Sb	(159.4^{III})
[1]Si	As	(173.7^{III})
[1]Si	Nb	(173.7^{III})
C	Nb	VII^{III}
Ge	Sb	$VIII^{III}$
Ce	V	B
Same line { C	V	La
Same line { C	As	La
(161.3^{IV})	(166^{V})	Tl (approx.)
Pb	Sb	Sc
Pb	Nb	Al
Th	pr Di	Yt
Same line { Th	As	Al
Same line { (161.3^{IV})	As	Al
(161.3^{IV})	Nb	Ga
Th	(166^{V})	Ga
Sn	Nb	B
Same line { $VIII^{IV}$	VII^{V}	(173.7^{III})
Same line { $VIII^{IV}$	VII^{V}	Tl
$VIII^{IV}$	Sb	(159.4^{III})
$VIII^{IV}$	Bi	In

Group II.	Group IV.	Group II.
Same line { Mg	Ge	Cd
Same line { Mg	(175.6^{IV})	Cd
$VIII^{II}$	Sn	Zn
Ca	Zr	(171.3^{II})
Hg	(161.3^{IV})	Ca
Be	Zn	$VIII^{IV}$

Group II.	Group IV.	Group VI.
Be	Ge	Te
Be	(161.3^{IV})	(212^{VI})
Ca	Zr	(167^{VI})
Ca	Ce	ne Di
Sr	(175.6^{IV})	W
Cd	Ti	O
Zn	(175.6^{IV})	U
$VIII^{II}$	Th	W

[1] The position of silicon necessary for this line is higher than shown on the chart. The specific gravity of silicon is variously stated.

Group I.	Group V.	Group V.
H	As	Ta
Li	As	Nb
K	pr Di	(166[V])
Cu	(166[V])	Bi
Cu	V	N
Au	Ta	P (red)
Au	(166[V])	pr Di

Several approximate lines are not given; *e. g.*, Cr, Ta, and V. The coincidences are less perfect with the elements of Group V than with all other elements.

	Group II.	Group II.	Group III.
	Be	(154.5[II])	VIII[III]
	Ca	(154.5[II])	Tl
Same line	Be	(154.5[II])	In
Same line	Be	(154.5[II])	VIII[III]
	Hg	Cd	Ga

	Group II.	Group II.	Group II.
	Cd	Ba	VII[II]
	Be	Zn	Cd
	Mg	(171.3[II])	Hg

	Group II.	Group V.	Group IV.
	Be	As	Ce
	Be	V	Sn
	Mg	As	(175.6[IV])
	Mg	(166[V])	Pb
	Hg	(166[V])	Zr
Same line	Hg	Nb	[1]Si
Same line	Hg	As	[1]Si
Same line	(171.3[II])	As	[1]Si
Same line	(171.3[II])	Nb	[1]Si
Same line	(154.5[II])	Sb	[1]Si

	Group II.	Group VI.	Group IV.
Same line	Zn	Mo	Th
Same line	Zn	Mo	VIII[IV]
Same line	Cd	Mo	(161.3[IV])
Same line	Cd	Mo	C
	Be	(212[VI])	(161.3[IV])
Same line	Be	Cr	Pb
Same line	Be	(167[VI])	Pb
Same line	Be	Mo	Pb
Same line	Mg	O	VIII[IV]
Same line	Mg	Se	VIII[IV]
	Ca	(212[VI])	Th
	Ca	ne Di	Pb

[1] See previous note on position of silicon.

	Group II.	Group VI.	Group IV.
	Zn, Ti, S, Ca	Te	(161.3^{IV})
	Be, Ge, Te, Ca	(167^{VI}	Zr
	Sr	W	Ce
	Sr	W	(175.6^{IV})
	Hg	(167^{VI})	Sn
	Hg	Te	(161.3^{IV})
	Zn	U	(175.6^{IV})
Same line	Zn	Cr	Sn
Same line	VIII^{II}	Cr	Sn
Approx.	Cd	U	Ti
Same line	Cd	O	[1]Ge
Same line	Cd	O	Ti
	Cd	Cr	(161.3^{IV})
Same line	VIII^{II}	Se	Si
Same line	VIII^{II}	Se	Ti
	VIII^{II}	Cr	Sn
Approx.	VIII^{II}	S	Zr

	Group II.	Group IV.	Group IV.
	Be	Th	VIII^{IV}
Same line	Mg	Sn	Pb
Same line	Mg	Sn	(161.3^{IV})
	Mg	Ge	175.6
	Ca	Ce	Pb
	Ba	Ti	C
	Sr	Ce	(175.6^{IV})
	Cd	Ge	(175.6^{IV})
	Cd	Th	VIII^{IV}
Same line Approx.	Hg	Ge	Si
Same line Approx.	(171.3^{II})	Ge	Si
Same line Approx.	Hg	Ge	Ti
Same line Approx.	(171.3^{II})	Ge	Ti
	Hg	(161.3^{IV})	Zr
	VIII^{II}	Ce	Ge
	VII^{II}	Zr	Ti
	(171.3^{II})	Pb	Th

	Group II.	Group VI.	Group VI.
	Ba	S	O
	Ba	Se	Cr
	Ca	Te	U
	Sr	167^{VI}	W
	(171.3^{II})	Se	U
	Cd	S	W
Approx.	Be	Cr	Mo
Approx. only.	Mg	Se	ne Di
Approx. only.	Mg	Te	ne Di

[1] Point a little high.

	Group II.	Group VI.	Group III.
	171.3^{II}	Te	Yt
	171.3^{II}	Se	Sc
	171.3^{II}	S	In

	Group IV.	Group V.	Group V.
Same line	C	V	As
Same line	C	V	pr Di
Same line	Ti	As	Nb
Same line	Zr	Sb	Ta
Same line	Ge	P	Ta
Same line	Si	As	Nb
	[1]Sn	P	(166^{V})
	Pb	Sb	N
Same line	Ge	(166^{V})	VII^{V}
Same line	Si	(166^{V})	VII^{V}
	Ce	[2]Sb	Nb
	Pb	[2]Sb	N
	$(VIII^{IV})$	Bi	As
	$VIII^{IV}$	(166^{V})	V
Approx.	(161.3^{IV})	(166^{V})	Sb
	(175.6^{IV})	Nb	P

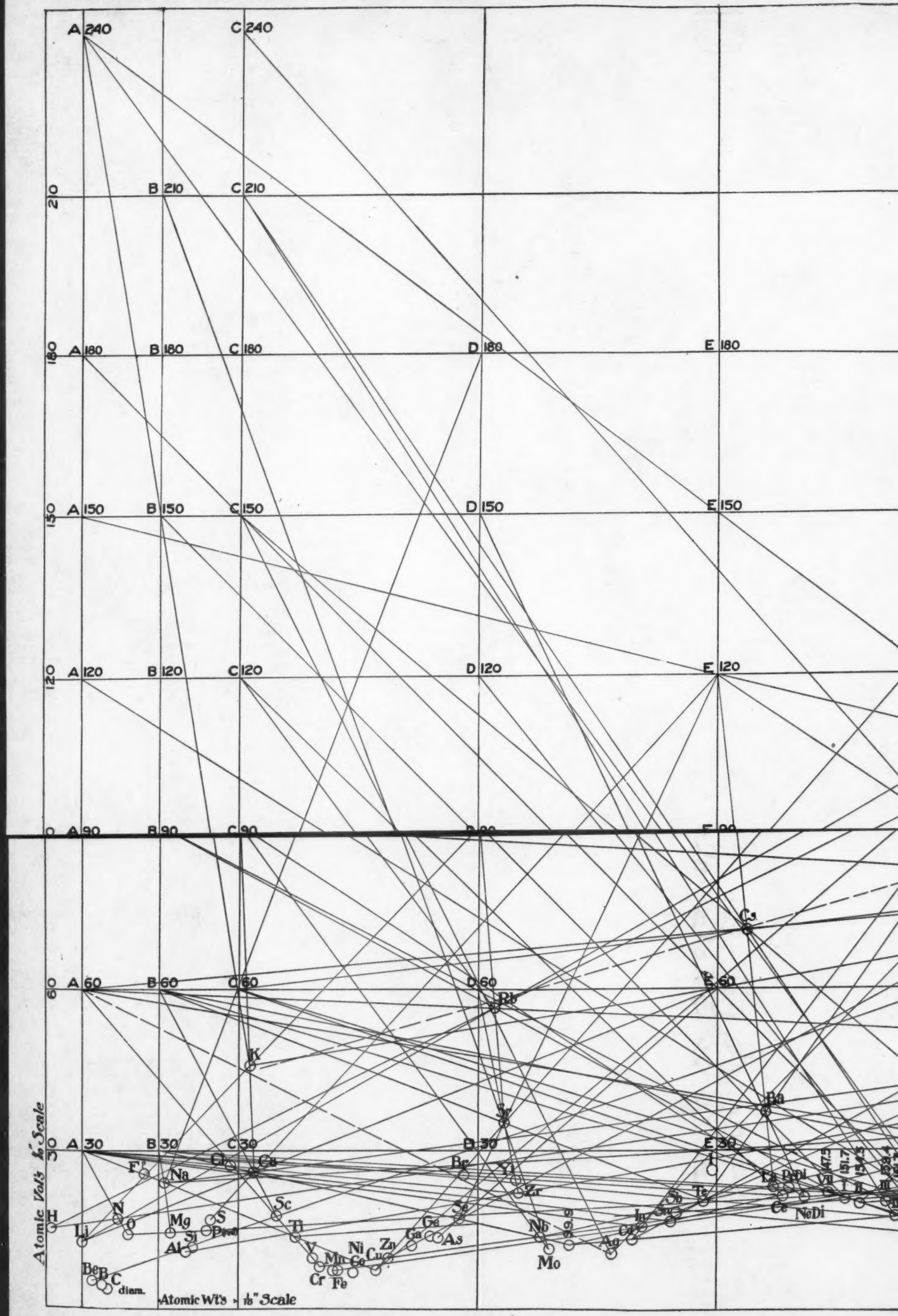
	Group I.	Group VII.	Group I.
	Na	Cl	VII^{I}
	Li	99^{VII}	Cr
	Li	(151.7^{I})	(214.8^{VII})
	K	I	Au
	K	(147.5^{VII})	(169.4^{I})
	Cu	Mn	Au
Approx.	Li	(186.7^{VII})	Ag
Approx.	Cu	168.8^{VII}	Ag
	Cu	F?	Na
	Cu	(186.7^{VII})	Cr
	Rb	(186.7^{VII})	(169.4^{I})
	Cr	F?	(169.4^{I})
	Au	I	(151.7^{I})
	Cr	B	(151.7^{I})

List of Elements with Specific Gravities and Atomic Weights Used in Preparation of Chart of Atomic Volumes.

Element.	Atomic weight.	Atomic volume.	D.
Aluminum	27.02	10.4	2.583
Antimony	120.0	17.9	6.697
Arsenic	74.9	13.1	5.725
Barium	136.8	(36.5)	(3.74)
Beryllium	9.08	4.9	1.85

[1] This and several other lines point to a slightly lower atomic volume for Sn.
[2] This and several other lines point to a slightly lower atomic volume for Sb.

Element.	Atomic weight.	Atomic volume.	D.
Bismuth	208.0	20.8	10.00
Boron	10.97	4.1	2.68
Bromine	79.75	25.0	3.188
Cadmium	111.7	13.08	8.546
Cadmium	111.7	12.91	8.65
Caesium	132.7	70.6	1.88
Calcium	39.91	(*c* 25.3)	(1.557)
Carbon (dia.)	11.97	3.4	3.518
Cerium	139.9	20.8	6.73
Chlorine	35.37	26.6	1.33
Chromium	52.45	7.71	6.8
Cobalt	58.8	....	....
Copper	63.2	7.06	8.945
n-Didymium	....	....	....
pr-Didymium	....	....	....
Fluorine	....	....	....
Gallium	69.9	11.7	5.96
Germanium	72.32	13.2	5.469
Gold	196.7	10.2	19.3
Hydrogen	....	....	....
Indium	113.4	15.3	7.42
Iodine	126.53	25.8	4.917
Iridium	192.5	8.6	22.42
Iron	55.9	....	....
Lanthanum	138.2	22.4	6.163
Lead	206.4	18.2	11.35
Lithium	7.01	11.9	5.89
Magnesium	24.0	14.0	1.71
Manganese	55.0	6.86	8.01
Mercury	199.8	14.7	13.596
Molybdenum	95.9	11.1	8.64
Nickel	58.6	6.5	8.97
Niobium	94.0	13.3	7.06
Nitrogen	....	....	....
Osmium	190.3	8.5	22.447
Oxygen	15.96	....	.
Phosphorus (red)	30.96	14.7	2.106
Platinum	194.3	9.0	21.5
Potassium	39.04	45.1	8.65
Rhodium	102.7	8.48	12.1
Rubidium	85.2	56.0	1.52
Ruthenium	101.4	8.03	12.63
Scandium	....	....	....
Selenium	78.8	16.7	4.7
Silicon	28.3	11.4	2.49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C 240
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Atomic Vols ½" Scale
H
Li
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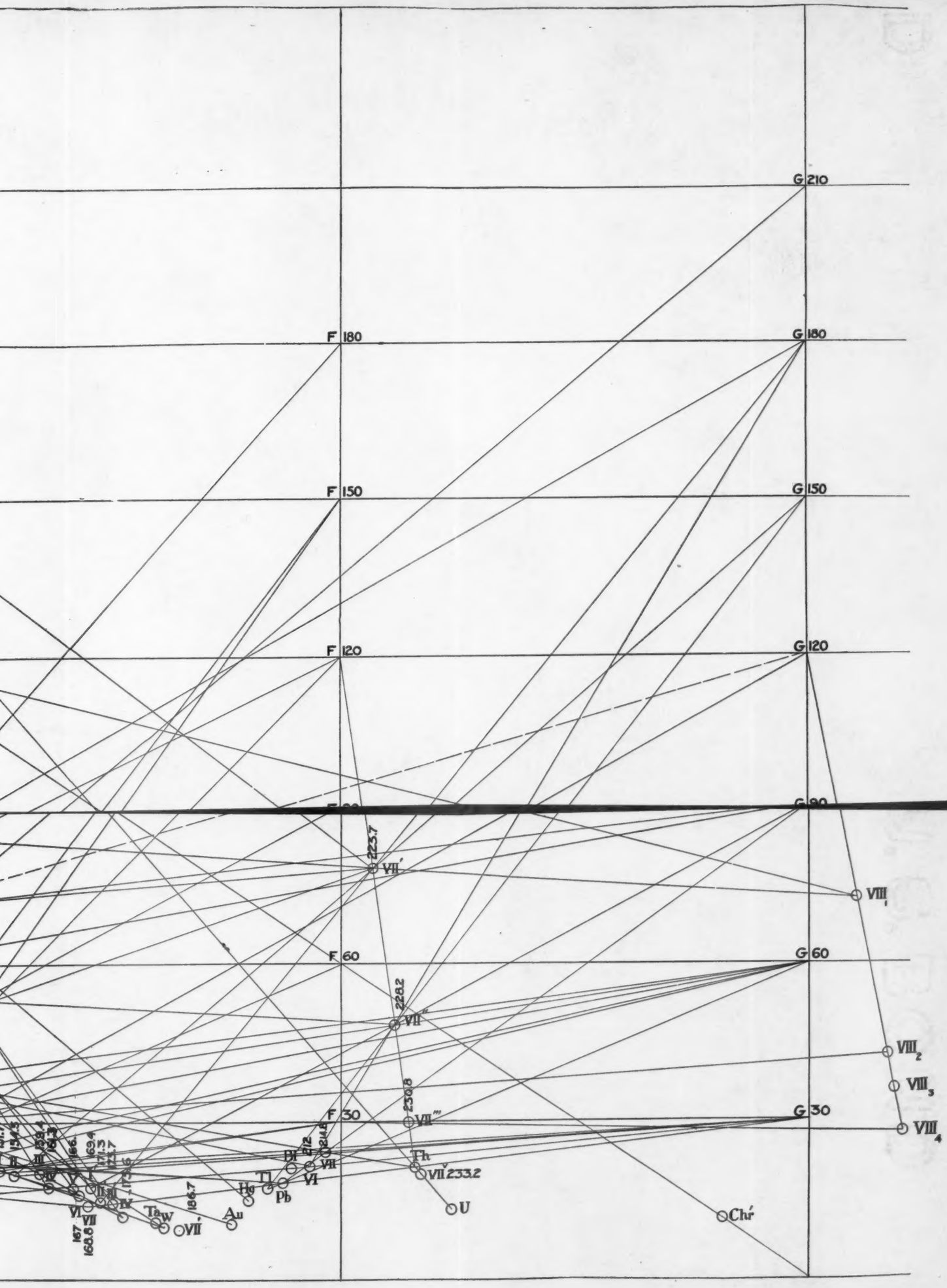
PrDi
NdDi
Atomic Wt's ½" Scale


G 210
F 180
G 180
F 150
G 150
F 120
G 120
G 90
F 60
G 60
F 30
G 30
223.7
VII'
VIII1
228.2
VII''
VIII2
VIII3
230.8
VII'''
VIII4
Th
VII 233.2
U
Chr
Hg
Tl
Pb
Au
Ta W
VII'
VI
VII
Bi
VII
VI
VII
VI
VII
VII
VII

Element.	Atomic weight.	Atomic volume.	D.
Silver	107.66	10.18	10.57
Sodium	22.995	23.3	0.985
Strontium	87.3	35.0	2.5
Sulphur	31.98	16.4	1.958
Tantalum	*c* 182.0	....	....
Tellurium	*c* 125.0	20.0	6.255
Thallium	203.64	....	11.81
Thallium	203.64	....	11.91
Thorium	232.0	20.9	11.1
Tin	118.8	16.3	7.3
Titanium	47.9	13.3	3.59
Tungsten	183.6	9.6	19.13
Uranium	239.0	12.8	18.685
Vanadium	51.2	9.3	5.5
Zinc	65.3	9.4	6.9
Zirconium	90.0	21.2	4.25

REMARKS ON LIST OF ELEMENTS.

Barium.—The lines cross at an atomic volume of 36.5, equal to 3.74 specific gravity. This is between the values recorded for the element, which vary from 3.5 to 4 (mean 3.75).

Bismuth.—The specific gravity of liquid bismuth at the melting-point is taken; this is the highest specific gravity of the element.[1]

Calcium.—The point taken in the chart was found by the crossing of the lines. It corresponds to an atomic volume of 25.3, equal to 1.577 specific gravity. Matthiessen gives 1.57, and this apparently is the only published result.

Germanium.—The point taken is *c* 15.34, which is a little too high. 15.3 would be better, and this corresponds to a specific gravity of 5.44. Winkler gives 5.469.

Hydrogen.—An atomic volume of 14.6 is assigned in the chart. This is about two-tenths higher than the figure recently given by Dewar. The lines drawn through this element place it in atom-analogy with Group I. It is sometimes placed in Group VII.

Silicon.—The lines indicate an atomic volume of 12.5, equal to 2.26 specific gravity. This value is between the values given by Wöhler (2.49 at 10° C.) and Winkler (2.149–2.197).

Strontium.—The point at which the lines intersect is 34.5,

[1] Vincentini: *J. Chem. Soc.*, *1891*, II, 518.

equal to 2.53 specific gravity. The determinations made with doubtfully pure specimens vary from 2.4 to 2.58.

Sulphur.—Deville's results for monoclinic sulphur.

Thallium.—The chart indicates a somewhat higher gravity (11.98) than Crookes obtained from the metal in the form of wire (11.91).

Zirconium.—The atomic volume apparently should be a little greater than 21.2.

THE OIL OF CORN.[1]

By C. G. Hopkins.

Received September 22, 1898.

THE presence of oil in the corn kernel was discovered by Bizio[2] in 1823. A partial analysis by Hoppe-Seyler[3] gave the following as the percentage composition[4] of the oil:

Cholesterol	2.65
Protogon	3.95
Saponifiable fats, etc	93.40

The statement is made that the oil contains stearin, palmitin, and much olein, and the melting-point of the fatty acids is given as 51° to 54° F. (11° to 12° C.).

Some of the so-called physical and chemical "constants," which have been determined by several investigators are given below:

	Specific gravity of oil at 15° C.	Unsaponifiable substance. Per cent.	Iodine absorption. Per cent.
Spüller[5]		1.35	119.7
Smith[6]	0.9244		122.9
Hart[7]	0.9239	1.55	117.0
Rokitianski[8]	0.8360		75.8

1 From advance sheets of the author's thesis "The Chemistry of the Corn Kernel," for the degree of Doctor of Philosophy, Cornell University, 1898, which will be published as Bulletin No. 53 of the University of Illinois Agricultural Experiment Station.

2 *J. Chem. u. Phys.*, *1823*, **37**, 377.

3 *Med. Chem. Untersuchungen*, **1**, 162; *Bull. Soc. Chim.*, *1866*, [2], **6**, 342; *Jsb. Fortschritte der Chem.*, *1866*, 698.

4 I have not been able to see Hoppe-Seyler's original paper. Presumably the protogon is the substance now termed lecithin, and the methods employed in estimating it and cholesterol were similar to those which are discussed herein.

5 Dingler's *poly. J.*, *1887*, **264**, 626.

6 *J. Soc. Chem. Ind.*, *1892*, **11**, 504.

7 *Ibid.*, 1894, **13**, 257, from *Chem. Ztg.*, **17**, 1522.

8 Inaugural Dissertation, St. Petersburg, *1894*; *Pharm. Ztschr. Russland*, *1894*, **33**, 712; *Chem. Centrbl.*, *1895*, [4], **7**, I, 22.

The oil used by Spüller was the ordinary ether extract. Rokitianski used a petroleum ether extract. Hart worked with a "dark brown" sample presumably found on the market. Smith's material was obtained on the market, but was of a "bright golden color" and was probably a fair sample of corn oil.

Spüller observed that the oil absorbed no oxygen from the air even after fourteen days' exposure. Smith states that the freezing-point of the oil is below —20°. Hart gives the melting-point of the fatty acids as 25°. Rokitianski reports further qualitative chemical work which showed the oil to contain oleic and linolic acids. It is evident from the specific gravity and the iodine absorption that the material with which he worked was not ordinary corn oil.

Wiley and Bigelow[1] have recently found the heat of combustion of oil of corn to be 9280 calories per gram.

EXPERIMENTAL.

In a preliminary study a small amount of oil was obtained by collecting the ether extract from a large number of proximate analyses of corn. In this, advantage was taken of the fact that the oil is moderately soluble in alcohol when hot and but slightly so at ordinary temperatures.[2]

The oil was transferred from the small flasks, used in its extraction, by means of hot alcohol to a single vessel. On cooling the oil precipitated and settled to the bottom, the alcohol being each time decanted from the collected oil, and used in transferring the next lot. Finally the alcohol was evaporated, and the oil dried to constant weight in a water oven. When freshly obtained from white dent corn the oil is nearly colorless, but on standing a pale yellow and finally a deep golden color develops, plainly indicating a gradual change in its condition, presumably due to absorption of oxygen. This was confirmed by determining the iodine absorption which was found to be 115.5 per cent.

A large quantity of corn oil, including samples from four different sources,[3] was then secured in order to make a more

[1] This Journal, 20, 309.

[2] Smith has found the solubility of corn oil in alcohol by volume to be two per cent. at 16° and thirteen per cent. at 63°.

[3] Samples of corn oil were very kindly furnished me by President Wm. F. Piel, Jr., of The National Starch Manufacturing Company, New York City; by The Chas. Pope Glucose Company, Geneva, Ill.; by The Glucose Sugar Refining Company, Chicago; and by Messrs. Elbert and Gardner, New York City.

thorough investigation. The oil is obtained as a by-product in the manufacture of corn-starch and glucose-sugar, and all of the samples secured were of a pale straw color and evidently fresh and pure.

SPECIFIC GRAVITY.

Three of these samples of corn oil were sufficient in quantity to enable me to make determinations of their specific gravity by means of a delicate Westphal balance which by trial gave the specific gravity of pure water at 15° as 1.000°. The samples of oil gave the following results:

	I.	II.	III.
Specific gravity at 15°.....	0.9245	0.9262	0.9258

MELTING-POINT.

Preliminary experiments confirmed the observation of Smith that the oil is still fluid at —20°, a temperature of —23° (obtained with snow and concentrated sulphuric acid) failing to solidify the oil. It was found, however, that the oil became hard and solid at about —36°.

The melting-point was determined by a modification of the method of the Association of Official Agricultural Chemists.[1]

In a tall beaker of about two and five-tenths liters' capacity was placed a small quantity of concentrated sulphuric acid (to absorb water vapor so that the apparatus would remain transparent at low temperatures). A second beaker of about two liters' capacity was placed in the first, being supported by the rim without touching the bottom. A one-liter beaker taller than the second was placed in the latter and filled with alcohol, the space between the two being filled with solid carbon dioxide. A glass tube thirty mm. in diameter and closed at the bottom was fitted into the inner beaker with a large cork, the tube being about one-third filled with a mixture of one volume of concentrated sulphuric acid and three volumes of absolute alcohol, and then nearly completely filled with absolute alcohol. The temperature of the alcohol in the beaker was kept uniform throughout by constant stirring with a wire which passed through the cork and terminated in a ring surrounding the glass tube. A heavy glass spoon and a glass spatula were placed in the alcohol.

[1] U. S. Dept. of Agr., Div. of Chem., Bull 46, 34.

When the temperature reached —50°, the spoon was removed and a drop of the oil at once let fall upon it. A thin, solid, white, opaque disk formed, and was quickly made to drop into the inner tube by using the glass spatula. The disk of solidified oil settled through the absolute alcohol to the denser liquid below and there remained in suspension.

The beaker which had contained carbon dioxide was replaced by another and the temperature allowed to slowly rise. An alcohol thermometer was used for reading the temperatures below the freezing-point of mercury. Above —38° a delicate mercury thermometer was employed.

As the temperature rose the disk remained unchanged until at —19° it began to lose its opacity. At —14° it had become perfectly transparent, but no change in shape could be detected below —7°. The disk was much contracted and thickened at —5° and became entirely symmetrical in form at —2.3°. A second determination gave practically the same results, the final reading being —2.4°. The change in temperature (when near the melting-point) required five to six minutes for one degree.

To determine the change in the consistency of the oil, a thin-wall tube of eight mm. diameter, closed at the bottom and containing one cm. of the oil, was placed in alcohol at —45°. After the oil had become solid a glass rod twenty cm. long and two mm. thick (the lower end being widened to five mm. diameter), was placed in the tube so that its weight was entirely supported by the solidified oil. At —13° the oil had become transparent but still supported the rod. At —10° the rod began to settle appreciably and at —9° it had passed through the centimeter of oil to the bottom, although a disk of oil suspended beside the tube in the same liquid had not changed appreciably in shape. The change of temperature from —10° to —9° required five minutes.

IODINE ABSORPTION.

The method of Hübl[1] was employed for this determination, except for certain details of the process.

Standard sodium thiosulphate solution was prepared by dissolving 47.2 grams of the crystallized salt ($Na_2S_2O_35H_2O$) in water and diluting to two liters. From theory one cc. of this

[1] *J. Soc. Chem. Ind.*, *1884*, 3, 641.

solution should be equivalent to 12.06 milligrams of iodine if the salt were pure.[1] The solution was standardized with resublimed iodine with the following results:

Iodine taken	0.5160	0.5574 gram.
Thiosulphate solution required	42.9	46.4 cc.
Iodine equivalent to one cc	12.03	12.01 milligrams.

The average of these results, 12.02, was used in the following work:

The iodine solution, containing fifty grams iodine, and sixty grams mercuric chloride in two liters of alcohol, was standardized whenever used.

Little pipettes of about five-tenths cc. capacity were placed in five cc. vials nearly filled with the corn oil, the bulb of the pipette being immersed, and the whole weighed. The measure of oil was then transferred to a 500 cc. glass-stoppered bottle, the pipette returned to the vial, and the exact weight of oil taken determined by difference. The duplicate is taken immediately and necessitates only one more weighing. Ten cc. of chloroform and forty cc. of iodine solution were added to the oil. After two hours twenty-five cc. of ten per cent. potassium iodide solution and about 125 cc. of water were added and the excess of iodine determined by titrating with the sodium thiosulphate solution, starch indicator being added near the close of the reaction.

Duplicate determinations of four different samples of oil from as many different sources gave the following results:

	Oil taken. Gram.	Iodine absorbed. Gram.	Iodine absorbed. Per cent.
1	0.3473	0.4255	122.5
	0.3844	0.4729	123.0
2	0.4251	0.5179	121.8
	0.4714	0.5729	121.5
3	0.4281	0.5212	121.7
	0.4742	0.5772	121.7
4	0.4326	0.5324	123.1
	0.5168	0.6351	122.9

OXYGEN ABSORPTION.

In order to afford a large surface for the absorption of oxygen, the oil was placed in a large crystallizing dish of seventy-five

[1] Sutton's Volumetric Analysis, *1890*, 115, states that standard sodium thiosulphate solution may be made by simply dissolving an exact weight of the crystallized salt, $Na_2S_2O_3 5H_2O$, in water and diluting to a definite volume.

mm. diameter. This was allowed to stand at the room temperature, the weight of the oil being determined from time to time as follows :

	Grams.
Weight of oil taken	2.1732
Weight after 1 day	2.1722
" " 7 days	2.1718
" " 11 days	2.1718
" " 12 "	2.1718

These results confirm those of Spüller, showing that the oil does not take up oxygen under these conditions.

The dish was then placed in a water-oven and the following data[1] obtained :

	Grams.
Weight after 1 hour	2.1726
" " 1 day	2.1996
" " 2 days	2.2488
" " 3 "	2.2590
" " 4 "	2.2588
" " 5 "	2.2558
" " 6 "	2.2513
" " 7 "	2.2448

The first action of air upon the hot oil is evidently the direct addition of oxygen ; but after two or three days the oil began to turn noticeably darker in color and finally to lose weight, evidently due to a secondary reaction which effects some decomposition of the oil with formation of volatile products.

LECITHIN.[2]

A weighed quantity of oil was mixed with potassium nitrate and sodium carbonate in a platinum dish and ignited until the carbon was completely burned. The fused mass was dissolved in dilute hydrochloric acid, and the total phosphoric acid determined.[3] The amount of lecithin was calculated by multiplying the weight of magnesium pyrophosphate obtained by the factor

[1] These results emphasize the importance of avoiding the presence of oxygen in drying corn or corn oil in analytical work.

[2] Lecithin is commonly regarded as a compound of the base, neurine, with distearylglycerophosphoric acid, although one or both of the stearic acid radicals may be replaced by radicals of palmitic or oleic acid, and the neurine (trimethylhydroxyethyl ammonium hydroxide) is sometimes replaced by another base ; *e. g.*, betaine.

[3] Cf. Hoppe-Seyler, *Jsb. Fortschritte der Chem.*, *1866*, 744 ; Schulze and Frankfurt, *Landwirtschaftliche Versuchs-Stationen*, *1893*, **43**, 207.

7.25.[1] Duplicate determinations gave the following results:

	Grams.	Grams.
Oil taken	10.728	6.435
KNO_3 used[2]	10.0	35.0
$Mg_2P_2O_7$ obtained	0.0221	0.0132
Lecithin	0.1602	0.0957
	Per cent.	Per cent.
Lecithin in oil[3]	1.49	1.49

CHOLESTEROL.[4]

To determine cholesterol[5] about fifty grams of the oil were saponified on the water-bath with twenty grams of potassium hydroxide and 100 cc. of seventy per cent. alcohol. The soap was transferred to a large separatory funnel with 200 cc. of water and shaken first with 500 cc. of ether and then three times with 250 cc. of ether. The four portions of separated ether were combined, and the ether distilled, the residue being resaponified with two grams of potassium hydroxide and ten cc. of seventy per cent. alcohol. The solution was then transferred to a small separatory funnel with twenty cc. of water and shaken with 100 cc. of ether. After separating the aqueous layer the ether solution was washed four times with ten cc. of water, the ether solution being finally transferred to a weighed flask, the ether distilled and the weight of the dry residue (cholesterol) determined. Three determinations gave the following results:

	Grams.	Grams.	Grams.
Oil taken	50.16	53.50	54.24
Cholesterol obtained	0.7002	0.7114	0.7512
	Per cent.[6]	Per cent.	Per cent.
Cholesterol in oil	1.40	1.33	1.38

The cholesterol was recrystallized from absolute alcohol in characteristic glistening plates, melting at 137° to 137.5°. It also gave the characteristic color reactions[7] for cholesterol: (1)

[1] 7.25 parts of lecithin ($C_{44}H_{90}O_9PN$) yield one part of magnesium pyrophosphate.

[2] The proportions of potassium nitrate used were purposely varied, but the results indicate that the smaller proportion was sufficient.

[3] By extracting corn with ether and alcohol, successively, Schulze and Frankfurt (reference above) have obtained amounts of phosphoric acid equivalent to 0.25 to 0.28 per cent. of lecithin in the corn.

[4] A monatomic alcohol, $C_{26}H_{43}OH$.

[5] Cf. Bömer, *Ztschr. für Untersuchung der Nahrungs- und Genussmittel*, 1898, 21, for recent work on the details of this method.

[6] Spüller had obtained 1.35 per cent. and Hart 1.55 per cent. of unsaponifiable matter.

[7] Watts' Dictionary, *1889*, 2, 147.

when shaken with chloroform and sulphuric acid; (2) when evaporated to dryness with nitric acid; (3) when warmed with hydrochloric acid and ferric chloride.

TOTAL FATTY ACIDS.

After removing the cholesterol from about fifty grams of oil the remaining soap solution (about 500 cc.) was acidified with hydrochloric acid and shaken in a separatory funnel. An ethereal layer of about 150 cc. at once separated. After adding 100 cc. more ether and thoroughly shaking, the aqueous layer was drawn off, the ether solution of the fatty acids washed with several portions of water and then transferred to a weighed flask, the ether distilled off, a few cubic centimeters of absolute alcohol dissolved in the residue and evaporated to remove traces of water, and the weight of the total fatty acids determined:

	Grams.
Oil taken	50.160
Fatty acids obtained	46.935
	Per cent.
Fatty acids in oil	93.57

The fatty acids form a solid mass at 15°, but melt nearly completely at one or two degrees above, the last particles of solid disappearing at 23°. Prepared as described the fatty acids absorbed only 126.4 per cent. of iodine instead of 130.7 per cent. as calculated from the iodine absorption of the oil. This indicates that oxygen had been absorbed by the acids during the process of separation. It was found that oxygen is slowly absorbed by the fatty acids while standing in a desiccator at the ordinary temperature. At 100° the absorption is much more rapid although, as with the oil, secondary reactions soon begin at the higher temperature. The change in weight was found to be as follows:

Time. In days.	In desiccator. Grams.	In water-oven. Grams.
0	1.9685	2.2740
1	1.9692	2.3106
2	1.9717	2.3366
3	1.9777	2.3366
4	1.9847	2.3282
8	2.0231	....
12	2.0665	....
16	2.0911	....
22	2.1157	....
28	2.1293	....
34	2.1297	....

All action apparently ceased after about one month's time. A considerable portion of the fatty acids had separated in the solid form and of a pure white color, while the other portion remained a colorless, oily liquid.

It is of interest to note the apparent relation between the iodine absorption and the oxygen absorption by the fatty acids. As already shown the fatty acids as prepared absorbed 126.4 per cent. of iodine. If an equivalent amount of the bivalent oxygen may be absorbed instead of the univalent iodine then eight per cent. of oxygen should be taken up. The results show that 1.9685 grams of the fatty acids absorbed 0.1612 gram of oxygen, an amount equal to eight and two-tenths per cent.

Time would not permit the preparation of the fatty acids in a manner which would prevent the absorption of oxygen during the process, and then a repetition of the quantitative determination of the absorption. This is especially desirable in order to confirm the results as given above, and the writer expects to investigate this point more fully in the future.

VOLATILE ACIDS.

About five grams of oil were saponified in a 500 cc. flask with two grams of potassium hydroxide and forty cc. of eighty per cent. alcohol. After evaporating the last of the alcohol, 100 cc. of recently boiled water were added, the soap solution acidified with forty cc. of dilute sulphuric acid (1:10), a few pieces of freshly ignited pumice-stone added, the flask connected with a condenser by means of a safety bulb tube, and 110 cc. of distillate collected. After mixing, 100 cc. were passed through a dry filter and titrated with one-twenty-fifth normal barium hydroxide solution.

Four determinations gave the following results:

	Grams.	Grams.	Grams.	Grams.
Oil taken	4.506	5.894	5.671	5.718
	cc.	cc.	cc.	cc.
N/25 barium hydroxide required	1.3	1.5	1.4	1.3

As two blank determinations required one and three-tenths and one and five-tenths cc., respectively, of the barium hydroxide solution it is evident that the oil contains no volatile acids.[1]

[1] Spüller gives Reichert's number for the volatile acids as 0.33; Smith states that the oil examined by him contained volatile acids equivalent to 0.56 per cent. of potassium hydroxide; and Morse (New Hampshire Experiment Station Bulletin, *1892*, 16, 19) gives volatile acids as three and two-tenths per cent. in a sample of corn oil which absorbed 112.8 per cent. of iodine.

SEPARATION AND DETERMINATION OF FATTY ACIDS.

It has been found especially by Hazura[1] and his associates that the oxidation of unsaturated fatty acids by alkaline potassium permanganate serves as a basis for the approximate separation of several fatty acids. Under proper conditions the oxidation is chiefly confined to the direct addition of the hydroxyl group (OH) wherever "free valences" exist. The following shows the relations among several acids in the series containing eighteen atoms of carbon in the molecule :[2]

Unsaturated acids.	Saturated acids.
	Stearic, $C_{18}H_{36}O_2$.
Oleic, $C_{18}H_{34}O_2$, oxidizes to..dihydroxy stearic,	$C_{18}H_{34}(OH)_2O_2$.
Linolic, $C_{18}H_{32}O_2$,, oxidizes to tetrahydroxy stearic,	$C_{18}H_{32}(OH)_4O_2$.
Linolenic, $C_{18}H_{30}O_2$, oxidizes to hexahydroxy stearic,	$C_{18}H_{30}(OH)_6O_2$.

After removing the cholesterol from 53.5 grams of oil, the combined soap solution was heated till the dissolved ether was distilled, cooled, and diluted to two liters. Two liters of a one and five-tenths per cent. potassium permanganate solution were then gradually added with constant stirring. After ten minutes the precipitated manganese hydroxide was filtered off, and the clear filtrate acidified with hydrochloric acid. The precipitate thus formed was filtered off, washed, air-dried, and then extracted with ether. The residue insoluble in ether weighed, after drying, eighteen grams. It was extracted with boiling water until but two grams remained, which, when again extracted with ether, left a residue of six-tenths gram and soluble in boiling water.

The substance dissolved in hot water was practically completely precipitated as the solution cooled[3] and proved to be sativic acid (tetrahydroxystearic acid), as is indicated by the method of formation and by its solubility in hot water. The melting-point[4] of the dried substance was 157°–159°.

The quantitative synthesis of the potassium salt was effected by dissolving a weighed amount of the acid in warm alcohol and titrating with standard alcoholic potassium hydroxide solution :

[1] *Monatsh. Chem.*, *1886 to 1889*, 7 to 10.

[2] Cf. Hazura: *Ibid.*, *1887*, 8, 269.

[3] 2000 cc. of the filtrate from the precipitated sativic acid required only five-tenths cc. of fifth-normal potassium hydroxide to show alkalinity with phenolphthalein.

[4] Bauer and Hazura, *Monatsh. Chem.*, *1886*, 7, 225, give 160° as the melting-point of several samples of sativic acid, prepared in a manner similar to the above.

Sativic acid taken.	Potassium hydroxide required.	Per cent. potassium in product.[1]	Per cent. potassium (theory).[2]
1.000	0.1604	10.08	10.14

The ether solutions obtained as described above were combined and the ether distilled. The residue was solid at the room temperature, melted gradually as the temperature rose from 40° to 60°, and was found to absorb 79.2 per cent. of iodine, thus showing very incomplete oxidation of the unsaturated acids.

A second lot of corn oil (54.24 grams) was oxidized by alkaline permanganate, the cholesterol and then the dissolved ether having been previously removed. The soap was diluted to two liters and cooled to 0° by ice kept in the solution. A solution of potassium permanganate containing eighty grams in two liters of water was slowly added with constant stirring. After thirty minutes precipitated matter was filtered off and washed; the clear filtrate was acidified with 150 cc. of concentrated hydrochloric acid; the precipitated acids were filtered off, dried, and extracted with ether. The residue insoluble in ether (17.7 grams, was dissolved in boiling ninety-five per cent. alcohol. On cooling, the sativic acid separated in the crystalline form, melting at 161°–163°.

By distilling the ether from the solution obtained as above described, a brown residue (nine and five-tenths grams) was obtained which melted at 55° to 60° and showed an iodine absorption of only nine and two-tenths per cent.

The aqueous acid solution from which the insoluble organic acids had been precipitated by hydrochloric acid was evaporated nearly to dryness, a black tarry mass gradually separating, showing that, although a small amount of unsaturated acids had been unacted upon, the oxidation had gone far beyond the simple addition of hydroxyl groups to the unsaturated compounds.

To further investigate the fatty acids, a method essentially that of Muter[3] was tried for their separation and determination. It is based upon the fact that the lead salts of the unsaturated acids, oleic, linolic, etc., are soluble in ether; while the lead salts of the saturated acids, stearic, palmitic, etc., are not.

[1] Calculated weight $=1.000+0.1604\frac{39.14-1.008}{56.148}$

[2] For $C_{18}H_{31}(OH)_4O_2K$.

[3] *Analyst*, 1877, **2**, 73.

About one and five-tenths grams of the oil were saponified with alcoholic potash and the soap dissolved in water, the unsaponifiable substance (cholesterol) being separated from the soap solution by shaking with ether. The solution was then neutralized with acetic acid, and the fatty acids precipitated with lead acetate, a slight excess being added. The lead salts were washed with water, and then transferred with fifty cc. of ether to a glass cylinder of about sixty cc. capacity, which was stoppered and then violently shaken for five to ten minutes. The small quantity of matter insoluble in ether was then allowed to settle. A stopper carrying two glass tubes similar to those used in the ordinary washing bottle was placed in the cylinder, the long tube reaching nearly to the undissolved sediment. By blowing in the short tube the clear solution is transferred almost completely without disturbing the sediment. The undissolved substance was then shaken with more ether, allowed to settle, and the ether transferred as before as completely as possible. This treatment was twice more repeated. The undissolved lead salt was then warmed with about twenty-five cc. of dilute hydrochloric acid, till the fatty acid separated; and, after cooling sufficiently, the whole was transferred to a 250 cc. graduated bulb tube, ether being used to complete the transfer. The portion of the tube below the bulb contained fifty cc. and was graduated to two-tenths cc. A small glass tube carrying a stopcock was sealed in just below the fifty cc. mark. The tube was filled to the 250 cc. mark (above the bulb) with ether, and thoroughly shaken. The aqueous layer, containing the excess of hydrochloric acid and the precipitated lead chloride was allowed to separate.

The volume of ether solution was observed, and 200 cc. of it were drawn off into a weighed flask, evaporated to dryness, and the weight of the residue determined.

Duplicate determinations gave the following:

	Grams.	Grams.
Oil taken	1.60	1.610
	cc.	cc.
Volume of ether solution	222.4	221.0
Ether solution taken	200.0	200.0
	Gram.	Gram.
Saturated acids obtained	0.0670	0.0648
	Per cent.	Per cent.
Saturated acid in oil	4.66	4.44

The residue of saturated acids formed a white solid mass. It was dissolved in hot alcohol and allowed to crystallize. The melting-point was 57°. The quantity of the saturated acids thus obtained was considered too small for further satisfactory examination (see foot-note below).

Before the lead salts of the saturated acids were completely washed by decantation[1] the clear ether solution of the lead salts of the unsaturated acids absorbed oxygen, and became cloudy, a white precipitate forming in considerable amount. Two samples of the atmosphere in the cylinders above the solutions were drawn off in gas burettes; and, after removing the ether vapor, the residual air was found to contain only 15.3 per cent. and 13.9 per cent., respectively, of oxygen instead of 20.8 per cent. as found in the air of the laboratory.

By subtracting the percentage (4.55) of saturated acids found in the oil from that of the total fatty acids (93.57) the amount of total unsaturated acids is found to be 89.02 per cent., consisting of oleic and linolic acids. (The melting-point of the sativic acid obtained and the composition of its potassium salt prove the absence of linusic acid in the products of oxidation, and, hence, of linolenic acid in the total fatty acids.)

From the iodine absorption, the amounts of oleic and linolic acids can be accurately determined. Thus:

Oleic acid, $C_{18}H_{34}O_2 + I_2 = C_{18}H_{34}I_2O_2$, diiodostearic acid.
Linolic acid, $C_{18}H_{32}O_2 + 2I_2 = C_{18}H_{32}I_4O_2$, tetraiodostearic acid.

As 89.02 grams of these unsaturated acids in the ratio in which they exist in corn oil absorb 122.3 grams of iodine the following equation can be stated, x being the number of grams of oleic acid:

$$x\,\frac{254}{282} + (89.02 - x)\,\frac{508}{280} = 122.3$$

The oleic acid is found to be 42.92 grams and the linolic acid 46.10 grams.

By subtracting from the amount of saturated acids the equiv-

[1] At least two days' time is required for this process, and even this was found more satisfactory than filtration. I have no doubt that, if centrifugal force were substituted for gravity, the washing by decantation could be done much better and so quickly that the unsaturated acids could also be determined before the absorption of any appreciable amount of oxygen. Quantities of the separated materials sufficient for further examination could doubtless be obtained in a short time. No suitable centrifugal was at hand for this work.

alent of the stearic acid contained in the lecithin, and calculating to the respective glycerol esters the remaining saturated acids (as stearic acid), the oleic acid, and the linolic acid, the following summary is obtained as the composition of the oil of corn:

	Per cent.
Cholesterol	1.37
Lecithin	1.49
Stearin (?)	3.66
Olein	44.85
Linolin	48.19
Total	99.56

SOME ERRORS IN THE DETERMINATION OF NITROGEN.[1]

By C. G. Hopkins.

Received September 22, 1898.

THE determination of nitrogen was made by the ordinary Kjeldahl method. The metallic mercury used in the digestion was measured in a capillary tube, one end of which is doubly bent so as to form a loop, the short arm of which is turned back upon itself near the end while the long arm serves as a handle. The loop is made sufficiently narrow to pass into the mercury bottle, and of sufficient length to retain, when raised above the liquid, the exact quantity of mercury required for a single determination. By blowing in the longer arm the mercury is emptied into the digestion flask.

Heavy copper flasks were used in the distillation with much satisfaction, the sodium hydroxide solution (containing the necessary amount of potassium sulphide) being added in sufficient excess to "bump" before the contents may become dry, thus serving as a signal that the distillation has gone far enough.

Two common sources of error in the nitrogen determination were found and investigated. In titrating an acid solution in an open vessel with standard ammonia solution a very appreciable error is introduced by the volatility[2] of the ammonia, although the only possible loss is from the tip of the burette and from the falling drops.

[1] From advance sheets of the author's thesis, "The Chemistry of the Corn Kernel," for the degree of Doctor of Philosophy, Cornell University, 1898, which will be published as Bulletin No. 53 of the University of Illinois Agricultural Experiment Station.

[2] Rempel has already shown that dilute ammonia solution drawn into beakers or evaporating dishes and then titrated suffers marked loss.—*Ztschr. angew. Chem.*, *1889*, 331.

In the following work ammonia of about one-sixth normal strength was used, the hydrochloric acid being of such strength that three cc. were equivalent to approximately four cc. of ammonia. The hydrochloric acid was measured from an automatic overflow pipette of fifteen cc. capacity, and the ammonia from an automatic overflow burette graduated to 0.05 cc. and drawn to a fine tip at the outlet. The pipette and burette were each provided with three-way stop-cocks through which the standard solutions were drawn from the stock bottles by means of siphons. Perfectly neutral water free from ammonia and carbon dioxide was used for diluting. Lacmoid served as the indicator and gave an exceedingly sharp end-reaction.

By titrating in beaker flasks with the tip of the ammonia burette well below the top of the flask the following results were obtained, the length of time taken in making the titration being also given :

No.	Hydrochloric acid taken. cc.	Ammonia required. cc.	Time, minutes.
1	15	20.10	1
2	15	20.08	1
3	15	20.12	1
4	15	20.30	2
5	15	20.25	2
6	15	20.40	3

By titrating in an Erlenmeyer flask attached to the burette by means of a rubber stopper,[1] provided with a capillary tube for relieving the pressure, the following results were obtained :

No.	Hydrochloric acid taken. cc.	Ammonia required. cc.	Time, minutes.
1	15	19.82	1
2	15	19.83	1
3	15	19.81	3
4	15	19.81	5

As from three to five minutes are taken to make a titration when the amount of ammonia required is not known, as in ordinary nitrogen determinations, the error[2] from titrating in open vessels becomes an important factor, the total variation in the two series of experiments above noted amounting to six-tenths

[1] By using a stopper which has been bored nearly through from the small end by a large borer, the flask may easily be given a free rotary motion.

[2] Confirmed by recent (unpublished) work of Dr. F. L. Kortright, of Cornell University.

cc. or three per cent. of the ammonia required. The fact that the density of ammonia gas is but little more than half that of air explains its rapid upward diffusion from an open vessel.

Another error in nitrogen determinations may occur in the distillation by loss of ammonia from the receiving flask in case there is not sufficient acid *above the end of the delivery-tube* to neutralize all of the ammonia distilled over.

In the following work a quantity of a very dilute solution of ammonium chloride was prepared by exactly neutralizing standard hydrochloric acid with standard ammonia and diluting with ammonia-free water. A quantity of this solution equivalent to twelve cc. of standard ammonia was placed in a distillation flask with an excess of sodium hydroxide and distilled into fifteen cc. of standard hydrochloric acid diluted to about forty cc., the end of the delivery-tube from the condenser dipping *well into the acid solution*. The relation of the standard acid and ammonia solutions was such that fifteen cc. hydrochloric acid were equivalent to 19.82 cc. ammonia. Six distillations were made, in each case ammonium chloride equivalent to twelve cc. of standard ammonia solution being taken. Following are the amounts of standard ammonia solution required to neutralize the excess of acid:

No.	Required. cc.	Calculated. cc.	Error. cc.
1	8.20	7.82	0.38
2	7.85	7.82	0.03
3	7.93	7.82	0.11
4	8.60	7.82	0.78
5	7.84	7.82	0.02
6	7.95	7.82	0.13

Two of these are practically exact, the other four showing errors varying from 0.11 cc. to 0.78 cc. of standard ammonia.

This work was repeated with the distillation from quantities of ammonium chloride equivalent to fifteen cc. of standard ammonia solution, the other conditions being as before. Following are the amounts of standard ammonia solution required to neutralize the excess of acid:

No.	Required. cc.	Calculated. cc.	Error. cc.
1	6.10	4.82	1.28
2	5.40	4.82	0.58
3	5.95	4.82	1.13
4	6.20	4.82	1.38
5	5.65	4.82	0.83
6	5.18	4.82	0.36

Diluting the residues in the distillation flasks with ammonia-free water, and distilling, gave no further addition of ammonia in any case.

It was observed that in both trials the greatest errors occurred with Nos. 1 and 4. A careful inspection of the apparatus showed all connections to be perfect. It was observed, however, that the delivery-tubes from Nos. 1 and 4 did not reach as far into the acid solution as most of the others.

With the thought that possibly ammonia escaped from the receiving-flasks, the following six distillations were made, in each the quantity of ammonium chloride employed being equivalent to 19.32 cc. of standard ammonia solution; thus, exactly five-tenths cc. of standard ammonia should have been required to neutralize the excess of acid. Some lacmoid indicator was added to the acid solutions in receiving-flasks Nos. 1, 3, and 5; strips of moistened red litmus paper were also hung in the necks of these flasks. During the process of distillation, receiving-flasks 2, 4, and 6 were agitated to keep their contents thoroughly mixed.

It was observed that, during the process of distillation, in receiving-flasks 1, 3, and 5 the liquid above the end of the delivery-tube turned blue, while a layer of liquid below this remained red; also that the moistened red litmus paper hung in the necks of these flasks turned blue.

In titrating the excess of acid the amounts of standard ammonia required were as follows:

No.	Required. cc.	Calculated. cc.	Error. cc.
1	2.60	0.50	2.10
2	0.50	0.50	0.00
3	2.27	0.50	1.77
4	0.53	0.50	0.03
5	1.99	0.50	1.49
6	0.50	0.50	0.00

The explanation for the separation of the liquid in the receiving-flasks into two layers as described is to be found in the different densities of aqueous solutions of ammonia and hydrochloric acid.

In subsequent work I have used delivery-tubes reaching to the very bottom of the receiving flasks, and contracted at the end to an aperture of but four or five mm. diameter. This insures considerable agitation of the contents of the receiving flask produced by irregularities in the boiling of the liquid in the distillation flask.

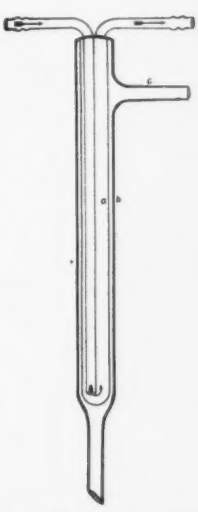
This loss of ammonia shown to have taken place from the very dilute solution in the receiving flask after cooling by an efficient condenser emphasizes the results of the preceding work on titration and the importance of avoiding a common error in that process.

A CONDENSER FOR EXTRACTION WORK.[1]

By C. G. Hopkins.

Received September 22, 1898.

MAINLY to avoid the constant trouble of having atmospheric moisture condense upon the outer surface of a Liebig or Allihn condenser and run down over the extraction apparatus, the following form of condenser was designed:



This condenser is made entirely of glass, and consists of a *thin* glass tube *a* twenty-five mm. *outside* diameter and twenty-five cm. long, provided with two glass tubes about six mm. in diameter, one reaching to near the bottom of *a*, sealed in for water inlet and outlet. The tube *a* is surrounded by a stronger glass tube *b* of thirty mm. *inside* diameter sealed on at the top and narrowed at the lower end to a ten mm. tube which extends eight mm. below and is ground off obliquely at the end. About

[1] From advance sheets of the author's thesis, "The Chemistry of the Corn Kernel," for the degree of Doctor of Philosophy, Cornell University, 1898, which will be published as Bulletin No. 53 of the University of Illinois Agricultural Experiment Station.

three cm. from the top of tube *b* a side tube *c* is provided ; it is five cm. long and twelve mm. inner diameter, and is widened, as indicated in the figure, where it is sealed into *b*. The water tubes are cut off at a length of five cm., being blown as indicated to hold a rubber tube.

The outer tube of this condenser is not cooled to a temperature at which atmospheric moisture will condense upon it. This is its chief advantage over the ordinary form in fat extraction with anhydrous ether. The side tube serves to connect with a drying tube.

A few other important points may be noted. The condenser may be used in ordinary distillation by passing the vapor in through the side tube. The ordinary condenser frequently breaks in consequence of the extreme differences in the temperature of the inner tube just above and below the surface of the surrounding water. The new form is free from this objection. The water tubes are both at the top and very convenient for joining up a series of condensers. These condensers are more compact and yet much more effective than the ordinary form, the vapor being distributed in a *thin* layer over a very large condensing surface, the outer tube also acting as an "air condenser."

These condensers have been in almost constant use during the past year in the chemical laboratories of the University of Illinois and have given excellent satisfaction.

There are several condensers which have the water tube inside, but I have found none suited to the purpose for which this was especially designed except that recently described by Sudborough and Feilmann[1], which is certainly to be preferred to the ordinary form as a return condenser, though it cannot be used safely in distillation.

[1] *J. Soc. Chem. Ind.*, *1897*, **16**, 979.

REVIEW.

SOME RECORDS OF THE YEAR'S PROGRESS IN APPLIED CHEMISTRY.[1]

To present in a single paper even a limited review of what the year has brought forth in the application of chemistry in the arts and manufactures is a difficult task. So manifold have been the discoveries of new facts and the new applications of old ones that to cover all that has been accomplished in the several fields would be beyond the capacity of any individual or of the space or time that could be devoted to a single paper. In the present instance, therefore, it will be possible to present only such as have specially interested the writer and seem to be of interest and value to those to whom this paper may come.

It was said of old "it is not well for man to be alone," and this applies to chemists as well as to those interested in other departments of human activity. Personal exchange of thought and experience is the best stimulus to further endeavor, and so the various meetings and Congresses do their share in the promotion of the interests which most nearly concern us. Of these, several have been held in various localities with most gratifying results. The Third Congress of Applied Chemistry was held in Vienna in the closing weeks of July and was well attended, while the work done was of the highest character. 765 members were in attendance. The Congress was divided into fifteen sections and subsections which held seventy-six separate meetings and discussed, in all, 171 subjects. At the closing session it was proposed and determined that the next meeting should be held in Paris, in 1900. The proceedings of the Congress will be published promptly and will constitute a valuable record of the more important advances made during the year.

Likewise the annual general meetings of the Society of Chemical Industry of England and of the Vereins Deutscher Chemiker of Germany, have been held and the work of these organizations, respectively, will be published in their own Journals.

Chemical industries are perhaps more flourishing and more widely extended in Germany than in other countries though they are becoming far more numerous from year to year everywhere. Doubtless the figures of Wenzel regarding Germany may be accepted as, in a measure at least, reflecting the conditions prevailing throughout all the countries in which such industries flourish. Thus he states that at the close of 1896, in Germany, 96 chemical works with 256,038,900 marks capital gave a total return of 31,495,900 marks in dividends, or an average of 12.3 per cent. against 8.9 for 1897. In these figures the tar

[1] Read before the New York Section of the American Chemical Society, Oct. 7, 1898.

industries gave the highest, nearly 24 per cent., and the fertilizer industries the lowest net returns. The general commercial and financial depression of the past years seem, therefore, to have influenced the chemical industries as well as many others.

In the metallurgical processes but little progress seems to have been made. In the extraction of gold and silver by chemical means the chlorination, bromine, and cyanide processes still hold favored places and they seem to have reached positions having little room for improvement. Most interesting, therefore, is the announcement that Dupre has been able to extract gold with an inexpensive solution containing sodium thiosulphate and ferric halides (chloride, bromide, or iodide) together with an acetate. The mixture of these substances together in water yields a dark red solution capable of dissolving gold and its compounds from sulphide and other ores without attacking the base sulphides. It is stated that a solution containing two per cent. sodium thiosulphate, 0.75 per cent. ferric chloride, and one to two per cent. calcium acetate and diluted to two, three, or even ten times its volume with water, will serve for the extraction of the most varied kinds of gold ore, and that for equal volume and equally exposed gold surface this solution will dissolve, in six to twelve hours, fifteen to twenty times as much gold as a one to two per cent. cyanide solution in equal time. The gold probably passes into solution as sodium gold thiosulphate which may be decomposed for recovery of the gold by zinc, by electrolysis or by the action of sodium nitrate and sulphuric acid. The process seems to be worthy of careful consideration.

The extraction of zinc, particularly when associated with other metals, has always been troublesome and costly and generally impracticable. In this direction more progress has probably been made than in any line of metallurgical work, and several successful methods for the economical and commercial separation of zinc from other metals have been devised during the past year or two. Ashcroft carefully roasts the ore and extracts the roast with sulphuric acid alone or in admixture with ferrous sulphate. The iron salt is decomposed by the zinc oxide, the zinc sulphate passing into solution; the solution obtained by filtration and washing the residue is concentrated until it contains 250 grams of zinc per liter and electrolyzed to removal of 75 per cent. of the dissolved metal. The solution is used on a new lot of ore, or the metal is recovered from it by precipitation. The lead residue is smelted for argentiferous lead.

Siemens likewise roasts the ore carefully, converts the gases into vitriol, extracts the roasted ore with the vitriol produced, electrolyzes the solution to separate the zinc and smelts the residues for argentiferous lead.

Hall leaches the carefully roasted ore with vitriol but he

decomposes the solution with magnesium carbonate, obtaining zinc carbonate which, by heating, he converts into zinc oxide.

Fry, David, and Ledoux, melt the carefully roasted ore with one-fourth its weight of sodium sulphate or bisulphate, and one-eighth its weight of iron oxide in a cupola furnace. It is stated that in the smelting process ninety per cent. of the lead is obtained as metal carrying all the gold and silver, the zinc passing into the fusible slag. The latter is heated with carbon in a Siemen's furnace, the reduced and volatilized zinc burned to oxide, which is collected in dust chambers, resulting in a recovery of eighty per cent. of the zinc. The process is applied in Swansea each week to 400 tons of ore containing twenty to thirty-five per cent. lead, twenty-five to thirty per cent. zinc, thirty ounces silver, and a little gold.

Frank in Berlin extracts zinc electrolytically in a mixed process. He uses a three-cell bath. The anode space contains alkali chloride; the cathode space an alkaline zinc solution and through the intermediate space separated from the others by diaphragms, alkali chloride solution is made to circulate. Zinc is collected at the cathode, chlorine at the anode, and the intermediate space is said to contain chloride and free alkali, the latter to be separated, and recovered by evaporation.

The electrolytic process of Hoepfner is applied to refining of zinc in England, with success and profit. It is stated that one E. P. yields one pound pure zinc, while refining of an equal weight of copper requires only half as much energy.

Tommasi proposes to replace other processes for desilverization of lead by electrolysis obtaining, at the same time, lead of the highest degree of purity. The electrolyte consists of a solution of acetates of sodium and lead. He uses a current of 6.75 volts and 1800 ampères for each bath, and reduces internal resistance by bringing the electrodes closely together. The metal dissolves from the anode, and is deposited on the cathode, whence it is carefully scraped off as cement lead which is fused with carbon, while the silver is deposited as slime. The inventor claims that lead containing 150 to 200 grams of silver per ton, can be profitably worked at a cost of ten francs per ton.

In the extraction of nickel, Mond seems to have made some further progress in the application of the carbonyl reaction. It will be remembered that he first reduces the oxide, and for the more effective action in the subsequent step, this should be done at a temperature not above 350° C.; that he next subjects the reduced metal to the action of carbon monoxide at a temperature of 50° to 60° C. which is most suitable for the reaction producing the carbonyl compound; he then subjects the latter compound to a higher temperature for its decomposition.

He has elaborated an apparatus for practically continuous

operation consisting of a "reducer" and a "volatilizer," but both these may be combined in the same apparatus. In a vertical cylinder are arranged alternately a series of plates and hollow boxes, one above the other. The boxes have the same diameter as the cylinder, and the plates are slightly smaller leaving an annular space at their peripheries. Each box has an opening at the center. A vertical shaft through the center with properly constructed stirring arms forces the material to be treated from the center of the plate to the periphery over which it falls to the surface of the box, and is drawn to its center when it falls to the next lower plate and so on in succession. The boxes are arranged to receive and discharge, at the will of the operator, steam, hot air, or cold water. The boxes of the upper part of the apparatus heat the ore to the reducing point, the boxes at the lower part cool it to the volatilizing point. When properly cooled it is sent to the volatilizer, and the treatment completed. The method seems likely to have practical application.

Storer extracts the metal from New Caledonian ores by heating the finely pulverized ore with ferric chloride solution in a closed vessel to a temperature of 190° C., five to eight hours. A solution of nickel chloride containing a little ferric chloride is obtained, and the latter is subsequently removed by lime.

Coehn bases a method for separation of cobalt and nickel upon the fact that in the electrolysis of the solutions containing them the former will separate as peroxide at the anode while the latter will not. Even in the presence of large quantities of nickel the cobalt deposit is free from it. To prevent the deposition of nickel at the cathode, a more easily separable metal such as copper (in form of sulphate) is added to the solution. It is believed that the reaction will find application both in the laboratory and in the works.

Lebeau produces beryllium (glucinum) by electrolysis of its double fluoride of sodium or potassium, using a cathode of nickel and an anode of carbon, and operates at a temperature corresponding with red heat with a current of eighty volts and twenty ampères. The metal obtained contained 99.5 to 99.8 per cent. beryllium, and had a specific gravity of 1.73. It does not oxidize in dry air but burns brilliantly in oxygen. Halogens attack it, and dilute acids dissolve it. It combines at high temperatures with nitrogen, boron, silicon, and carbon, and forms carbides, which with water yield the hydrate and methane. It forms alloys with other metals, those with copper being malleable, and capable of taking high polish which does not readily tarnish in the air.

Goldschmidt and Vautin made use of the very high heat of

combustion of aluminum, which is 360,000 calories, for the production of high temperatures, and the reduction of the very refractory metallic oxides, and by means of it has been able to separate chromium, titanium, manganese, iron, copper, etc. To effect this it is only necessary to intimately mix the finely pulverized oxide with very finely divided aluminum and start the combustion. It proceeds quickly to a finish, producing temperatures up to 3,000° C. and reducing the metals free from carbon.

Franck has likewise utilized the high combustion temperature of aluminum for the reduction of oxides both metallic and non-metallic and particularly for the production of phosphorus. For this latter purpose he mixes the metaphosphate with silica and aluminum, and heats the mixture to start the combustion when the reduction proceeds quietly ; the phosphorus distils readily and yields an excellent product particularly when the lime compound is employed.

Various other methods for production of phosphorus have been devised in which the electric furnace is employed to attain the high temperature requisite to proper reduction. Thus Hilbert and Franck and Gin and Leleux, working independently, heat properly proportioned mixtures of phosphatic material and carbon in the electric furnace, the ensuing reaction producing calcium carbide and phosphorus. The phosphorus volatilizes and is collected. Collardeau makes calcium phosphide in the electric furnace, generates hydrogen phosphide with it, and decomposes the gas by passing it through a strongly heated coke-lined tube, and collects the phosphorus liberated ; and Boubleque decomposes electrolytically the iron phosphide obtained by fusing together iron compounds and calcium phosphate, and removes the liberated phosphorus by a current of indifferent gas. In Germany the price of phosphorus has further declined and reductions of 0.40 M. for white and 0.80 M. for red are quoted. The production has increased in France, as well as in Russia, is extending to Germany where several works have been projected and the English monopoly is seriously threatened. Likewise at Niagara Falls, and elsewhere in this country, electrolytic processes have been applied and further fall of price may be expected.

Ronco has discussed the various electrolytic methods for production of white lead. From him we learn that Turner Bottome electrolyzes an alkaline salt solution containing sodium or potassium carbonate, between lead electrodes, passing a current of carbon dioxide through the solution during electrolysis. White lead is said to precipitate leaving the electrolyte unchanged. Ferranti and Noad use ammonium acetate as the electrolyte with lead electrodes separated by a diaphragm. After proper time

the anode and cathode liquors are mixed together and carbon dioxide passed through the mixture, and Luckow uses a solution containing one and five-tenths to two per cent. of a mixture of salts consisting of eighty parts of a salt whose acid makes a soluble salt with lead and twenty parts of alkali carbonate. He applies to this solution a current of five-tenths ampère per sq. dm. and two volts between anodes of soft lead and cathodes of hard lead while passing carbon dioxide through the electrolyte.

Progress in the alkali industry has been confined to the electrolytic processes so far as can be learned from the literature. We are told that in England the production of alkali by the Leblanc process has considerably declined while that by the Castner electrolytic process has increased, and the Hargreaves and Bird process gives promise of extension during the present year. The Kellner-Partington Paper Pulp Company at Sharpsborg, in Norway, have projected a large electric plant to utilize the water power of the place. In addition to this a new company, the "Hafslund Aktieskab", has been organized and will erect, on the other side of the falls, an electric plant of 25,000 horse-power, the latter to supply power for works, and for electrochemical works, particularly the manufacture of aluminum and carbide. The status of the utilization of power for generating electric energy for use in the alkali and bleach industries in Europe is illustrated in the following table:

Golling—water-power	3000	H. P.	in construction.
Solvay, Bernberg	1000	"	in operation.
Solvay, Belgium	2000	"	in construction.
Solvay, Russia	4000	"	projected.
Castner-Kellner, Runcorn, England	1000	"	in operation.
Castner-Kellner, Runcorn, England	4000	"	projected and in construction.
Chemische Fabrik, Gresheim, Bitterfeld	4000	"	in operation.
Algemeine Electricitäts, Gesellschaft, Bitterfeld	3000	"	in construction.
Electro-Chemical Co., St. Helens, England	1100	"	in operation.

Kellner of Halle, discussing the status of the electrolytic alkali industry in the International Congress of Applied Chemistry in Vienna, states that three processes are now used: (1) Electrolysis of alkali chloride with the aid of diaphragms; (2) electrolysis of a fused electrolyte; and (3) electrolysis of alkali chlorides with the aid of the mercury cathode.

The diaphragms which have given the best results, he says, consist of, first, salt, and second, soap or cement, all having the disadvantage that they need a low tension current, and large apparatus compared with the yield, low concentration of the alkali solution, and finally contamination of the latter with undecomposed electrolytes. He considers that electrolysis of the fused electrolyte leaves much to be desired.

The mercury diaphragm is most used, and has been variously applied by Sindig-Larsen, Castner, Strömers, Rhodin, and others. He denies any objection to their use from a sanitary standpoint, but states that flouring of the quicksilver must be avoided because of the tendency to formation of mercuric chloride with corresponding loss of mercury.

The Hargreaves and Bird process seems to be responding to the persistent work done with it, and shows promise of successful extension and development. Carbon anodes, and iron gauze cathodes are used and between them is arranged a diaphragm of secret constitution and construction. Steam washes the soda from the cathode, and chlorine from the anode is carried to a lime-box. Dr. R. Lucion, of Brussels, reported to the International Congress of Applied Chemistry, that his observations led him to consider that the probabilities of the ultimate successful operation of the process are slight. The diaphragm, he says, apparently consists of an iron screen upon which pulped asbestos has been floated, exhausted by suction and then saturated with a siliceous solution, and the general construction of the apparatus admits of the use of very impure solutions. The capacity of the apparatus referred to by Lucion is elsewhere stated to be: for each cell with ten square meters of diaphragm and cathode surface, decomposition of 106 kilos of salt producing, in twenty-four hours, 117 kilos of bleach of thirty-seven per cent. available chlorine, and 280 kilos crystal or 95 kilos calcined soda. This cell uses a current of 3.9 volts and 2300 ampères equivalent to 14½ E. P., costing $1.75 daily. The soda contained 97.7 per cent. sodium carbonate and one per cent. sodium chloride. Plans for enlarged construction have been projected but operations have thus far been carried on, apparently, only on a small scale.

Blount discusses the relative possibilities, cost, etc., of the Leblanc soda process and the electrolytic processes, and he finds that while the Leblanc process requires five and three-tenths tons of coal for one ton of caustic and by-products, the electrolytic process consumes but from three and two-tenths to four and two-tenths tons. He considers that although comparison of the two processes is very difficult it may be stated that the electrolytic processes are direct, clean, requiring inexpensive hand labor, and yielding no troublesome by-products, but on the other hand the apparatus required is extensive and costly and rapidly deteriorates.

The chemical processes give large yield with few pieces of apparatus but very large and inexpensive ones, requiring but little repair. Much hand labor is required, and an enormous quantity of worthless and troublesome waste-products result.

In the production of chlorates the electrolytic processes seem to

have taken the lead. Spilker and Lowe using a specially constructed apparatus electrolyze solutions of potassium chloride which in the anode cell is saturated with lime. The saturation of the anode liquid with lime, is maintained in the circulation which constitutes part of the process and the temperature is kept at 40° C when only chlorate is formed. Oettel likewise found that better yields may be obtained with a given current in producing calcium chlorate than is possible with potassium chlorate. Bischoff and Forster find the cause of this to be the lower solubility of the calcium hydroxide produced at the cathode and covering the latter with a thin layer thus minimizing its reducing influence. For best results they recommend a ten per cent. solution of calcium chloride, a current of ten ampères per square meter at the anode, and twice this strength at the cathode because of the calcium hydroxide formed on the latter. If the solution be heated to 50° C. the current tension is found to be the same as for potassium chloride.

Vaubel suggests addition of alkali bicarbonate to the anode liquid when alkali chlorides are being electrolyzed for he finds that in presence of the acid carbonates conversion of chloride to chlorate in the anode cell is complete. While the laboratory experiments gave satisfactory results, they were not confirmed by work on a larger scale.

The number of bleaching agents available in these latter years has been largely increased but much work remains to be done to perfect many of them. The old "bleach" (chloride of lime) still holds its place, yet the new bleaching processes are pushing it very hard. Thus the experiments of Cross and Bevan and of Clayton and Beadle show that bleaching with the Hermite solution consumes less chlorine for a given weight of fiber bleached while the time required for effective operation is enormously reduced. The relative efficiency of the Hermite solution and the chloride solution is as five to three. It was further found that the bleaching solution is more effective when kept in motion and that movement effects a saving of from thirty-seven to forty per cent.

The possibilities of the use of oxygen in its condensed forms seem to be growing with the development of improvements in the generation of electricity. Manufacture of sodium peroxide commercially is extending and the persulphates and percarbonates are attracting deserved attention. The process of Castner or some modification of it seems to be that almost exclusively used in the manufacture of sodium peroxide. The material is used in slightly alkaline solution, excess of alkali being controlled either by magnesium sulphate which is effective or by oil of vitriol.

Little has been added to the work of Marshall and Hansen in

the production of the persulphates and percarbonates. Low temperatures seem to be absolutely essential to their formation and that of persulphuric acid is likewise favored by the addition of small quantities of hydrochloric acid. Practical utilization of these products has not yet been reported. The use of ozone in bleaching is being applied by Siemens and Halske to the treatment of linen and yarns and of starch and its products, and they are devoting special attention to its production.

The production of chlorine by electrolysis is rapidly extending and must eventually, it would seem, replace other processes. The apparatus and methods of Castner and Kellner have found most favor but other and numerous ones have been devised. Yet as already stated practically all leave much to be desired. Hunt and Watson use ferric chloride in the cathode cell with an iron cathode, and potassium chloride in the anode cell and use the chlorine liberated for production of hypochlorite. Haber, on the other hand, electrolyzes strong hydrochloric acid directly and obtains a yield of 100 per cent. If the acid be dilute, hypochlorous acid is formed and with very weak acid oxygen is liberated.

Hammerschmidt and Hess have lately discussed in the *Chemiker Zeitung* the electrolytic production of oxygen, setting forth its advantages and a review of their statements will be of interest. They state that the gas produced by the Brin process contains only ninety per cent. and that obtained by the Linde liquefaction process only seventy-five per cent. of oxygen, and that either method consumes from one to three horse-power hours for the production of one cubic meter of gas.

A perfect electrolytic method remains to be devised, but of those which have thus far been brought forth by d'Arsenoval, Latchinoff, Renard, Dehnard, Siemens Brothers, Garuti and Schuckart & Co., the authors particularly commend that of the last named. The cells employed are of iron and hard rubber, the current used in practice 300 ampères and three and two-tenths to three and three-tenths volts, the temperature of the electrolyte which is a caustic soda solution, 60°C. With these conditions they have determined that sixty kilowatts or ninety horse-power will produce in twenty-four hours 100 cubic meters of oxygen and 200 cubic meters of hydrogen. This involves a plant costing something over $20,000 and a daily operating expense of between $30.00 and $35.00. Garuti's process yields *knall* gas at 4.15 pf. per cubic meter and oxygen at 12.5 pf. per cubic meter. If steam-power is used, twenty-one and sixty-two pf. respectively. Latchinoff likewise electrolyzes a sodium hydroxide solution of ten to fifteen per cent. in an iron vessel using a sheet iron anode enclosed in parchment paper stretched over an ebonite frame. The current tension is two and five-tenths volts and the cost of producing two cubic meters of hydrogen and one

cubic meter of oxygen is estimated at about sixty-five cents. The gases are of a high degree of purity and the processes therefore promise well for the future.

Kassner passes air over warmed calcium plumbate until oxidation is complete, removes residual nitrogen by steam, follows this with a current of carbon dioxide liberating the absorbed oxygen, purifies the latter by well-known means and claims to secure a product testing ninety-nine per cent. Lapointe heats a mixture of caustic soda and manganese dioxide in a current of air, exhausts the gas remaining at the close of the oxidation period, decomposes the manganate with superheated steam, and claims to obtain oxygen free from nitrogen.

Shenstone and Evans discussed, before the London Chemical Society, the influence of electrical tension upon atmospheric air. Under such influence air rapidly contracts, then quickly expands again, containing a trace of nitrogen tetroxide. In the presence of moisture eighty to eighty-five per cent. of atmospheric oxygen may be converted into ozone and with care the conversion may be carried to ninety-eight per cent. If not carried too far no nitrogen tetroxide is formed but there arrives a point at which this occurs. This compound favors the destruction of the ozone by the electric tension. The presence of moisture favors the production of ozone and hinders that of nitrogen tetroxide.

To reduce the temperature of the air and so favor the generation of ozone Andreoli constructs an apparatus with cooled electrodes, the latter consisting of rectangular boxes, each provided with inlet and outlet for cooling liquid and provided with its own circulatory system. Its surface is covered with pointed projections like saw-teeth. The air passes in at the bottom, and out at the top of the chamber in which these electrodes are enclosed.

The same principle influenced Otto in the construction of his apparatus for polymerization of gases and particularly oxygen by the electric spark or a current of high tension. To this end he frequently intermits the current and so prevents heating the apparatus. In one form he arranges two sets of electrodes one of which is fixed, the other parallel with the first and set in sectors of a movable disk. The two sets being properly enclosed and each connected respectively with the poles of a conductor carrying a current of about 18,000 volts, the disk is rapidly rotated causing its set of electrodes to successively pass those of the fixed part. With the current of the tension stated the electrodes should be about three centimeters apart. When the apparatus is in motion and the current is passing, rapid sparking ensues. If air or oxygen be passed between the active surfaces ozone is rapidly produced. In another form of apparatus two concentric cylinders are arranged, one with the electrodes in rings, the other or

inner one with the electrodes set spirally about it. The inner cylinder is made to revolve, and its electrodes rapidly pass in succession those of the outer cylinder. When the current is operating and air or oxygen is passed through the annular space, ozone is rapidly produced. Claim is made: (1) for the use of electrodes arranged, and used as described for effecting polymerization, combination or decomposition of gases, and (2) for producing ozone and other substances; for instance, cyanogen from nitrogen and acetylene, nitrated products from nitrogen and oxygen, ammonia from nitrogen and hydrogen. A similar form of apparatus is said to have been devised for utilization of Lord Rayleigh's plan for obtaining oxidized products from the atmosphere.

We may not leave the discussion of the forms of oxygen without some mention of liquid air which certainly gives some promise of application in an industrial way. It is interesting to note that the process for liquefaction of air depending upon the rapid cooling of the compressed gas by the expansion of a portion from a higher to a much lower pressure should have been brought out almost simultaneously by three different persons in as many countries. Linde in Germany, Hampson in England, and Tripler in this country seem to have attained the same end by the same means at about the same time. The process of Linde which does not differ essentially from that of the others named consists of an air-compressor and a return current apparatus. The air is first compressed to sixteen atmospheres, then to 200 atmospheres, and the water removed from it. Then it is passed through a coil enclosed within a second, the tubes of each coil being concentric. From the inner coil the air compressed to 200 atmospheres is allowed to expand into the annular space between it and the outer coil to sixteen atmospheres, and return to the compressor where it is again compressed to 200. A second compression and expansion reduces the temperature to the critical point and the air is liquefied. The entire apparatus is naturally protected by a non-conducting covering.

The liquid air so obtained contains thirty-seven per cent. oxygen and sixty-three per cent. nitrogen because of the more ready volatilization of nitrogen.

With a Linde machine it is possible to produce a mixture containing equal volumes of oxygen and nitrogen with a consumption of one horse-power for each cubic meter. It has been stated that the European practice yields about three-tenths liter per horse-power which is somewhat better than, so far as we can learn, has been attained in this country. There is no doubt, however, that with better apparatus, and the most economical power generation, much better results are possible.

With the low temperatures available through the rapid evaporation of the liquid air, new fields of interesting investigation of the physical properties of bodies and of chemical reactions, are made possible. Whether the oxygen-enriched mixture can be produced at sufficiently low cost and will be effective enough to be applied to such industrial reactions as the oxidation of hydrochloric acid in the production of chlorine or the oxidation of sulphur dioxide in the production of sulphuric acid as has been suggested, remains to be established ; but with proper arrangements for compression and for preservation of the liquid there seems to be no reason why it should not replace other agents, such as ammonia, sulphur dioxide, carbon dioxide, etc., in refrigeration.

In the production and utilization of calcium carbide, some progress seems to have been made; at any rate our knowledge regarding them has been considerably widened. Dr. Sieber discusses the heat requirements and finds a wide difference between those of theory and practice and justifies the efforts being made to improve manufacturing conditions with this regard. He estimates that one E. H. P. should yield 9.38 kilos of carbide in 24 hours, but in practice only four to five kilos are obtained showing that a large portion of the energy employed is consumed in heating the reacting mass. Again practice requires one and three-tenths kilos of carbon and one and four-tenths kilos of lime while theory requires six-tenths and nine-tenths kilos respectively, for one kilo of carbide. The power consumed, therefore, becomes 3230 watt-hours for heating and 1900 watt-hours for reaction. One E. H. P. should, therefore, yield in twenty-four hours 3.44 kilos. Since in the generation of electrical energy scarcely more than fifteen per cent. of the fuel energy is realized, it is plain that economy requires that the materials used should be heated before they enter the furnace and are subject to the action of the current. He suggests the use of the carbon monoxide generated for this purpose. If water-power is available, of course this is of less importance. Pictet likewise realized the importance of this, and has devised a specially constructed furnace having it in view. Into his furnace he charges coke and lime, the former being in considerable excess over that required for the final reaction. Into the upper of three zones he injects air, and by the resulting combustion of the excess of carbon a temperature of 2,000° C. is attained. Into the next lower zone he injects oxy-hydrogen gas, the combustion of which produces a temperature of 2,300° to 2,400° C. In the bottom zone are arranged electrodes with the arc immediately over an outlet. The carbide formed flows out through the opening and is collected underneath. Practical results of use of the furnace have not been given.

Hausermann recommends casting the carbon and lime into blocks or sticks before charging to the furnace, the principal object being to avoid production of partially converted dust which thus far has found no valuable application.

Regarding the cost of calcium carbide Desiré Korda states that one horse-power day should produce four kilos of carbide which would bring the cost to about $50 per ton.

The Neuhausen Company quotes the product at 300 francs, say $60 a ton. The author considers that the cost claimed by certain American producers is too low but the exports of the product from this country would not seem to confirm this.

It is now generally accepted by the best authorities that much of the danger and loss incident to the manufacture and use of acetylene is to be ascribed to the high temperatures produced in the generators employed. Gerdes reports that determinations of heat generated in the decomposition of calcium carbide shows it to amount to 1,200 calories for each kilogram of gas liberated. Lewes, operating with an apparatus of his own device, concludes that 406 calories fairly represent the heat of decomposition of one kilo of commercial carbide and he estimates that for pure carbide the figure should be 444.6. This varies somewhat from that given by Gerdes but the observers doubtless had different qualities of carbide. At any rate it is evident from the figures given that the temperature in the generators may readily reach the danger point. Pure acetylene suffers decomposition at 780° and Gerdes states that when mixed with a certain quantity of air this may even occur at 480°. Lewes, in a large series of experiments, found the temperatures in generators, in which a comparatively small quantity of water took part in the reaction, rose to from 703° to 807° in different cases. Under such circumstances, de Brevans states that polymerization occurs with the production of liquid hydrocarbons such as benzene, styrolene, etc., reducing the illuminating power. Acetylene produced by Lewes in his experiments and analyzed by him contained :

	I.	II.
Acetylene	70	69.7
Saturated hydrocarbons	11.3	11.4
Hydrogen	18.7	18.9

He states that this change reduced the illuminating power from 240 candles to about 126. Benzene is the principal product of the decomposition and is the most conducive to difficulties, such as stoppage of pipes by its condensation, of the burners by its decomposition, giving tarry products and giving smoky flames. Both Gerdes and Lewes recommend the use of large volumes of water in the generator, allowing the carbide to fall into the water; both recommend that the temperature shall not rise above 100° in the generator. Pictet even recommends that

the water used shall be cooled at 10° C. and be maintained at this temperature within the generator by special arrangement to that end. Bamberger likewise recommends using large quantities of water into which the carbide may fall in order to reduce the generation of ammonia from the nitrides and cyanides.

The poisonous qualities of commercial acetylene are believed to be due to the phosphorus and sulphur compounds it contains when recently generated. So likewise the dangerous character of the gas and its explosiveness are believed to be due to the presence of these compounds. This latter view is not sustained by the results of the experiments of Lewes which showed that in order that the gas may become spontaneously inflammable from such admixture it must contain over eighty per cent. of hydrogen phosphide. Lewes observed however that cases of spontaneous ignition occurred in the generation of gas when the carbide used contained even as low as one per cent. of calcium phosphide. Yet in spite of this fact, he expressed the opinion that ordinary commercial carbide could be used without danger from this cause.

Hubou finds the impurities of calcium carbide to be lime and coke, carborundum, silicides, nitrides, phosphides, arsenides, and sulphides. Lewes found the same impurities. It is natural therefore that the gaseous products of decomposition of these substances by water should be found in acetylene. So Girard found that gases containing 95.9 to 99.5 per cent. of acetylene, four-tenths to two and nine-tenths per cent. of nitrogen, 0.08 to 1.19 per cent. of carbon monoxide, and no oxygen, contained likewise per cubic meter two and seven-tenths grams of ammonia, 0.44 to 1.78 grams of hydrogen phosphide, 0 to 13.42 grams of hydrogen sulphide. Lewes found an average of 0.65 per cent. of hydrogen phosphide between limits of 0.02 and 2.30 per cent. DeBrevans found hydrogen phosphide, silicide, and sulphide, ammonia, ammonium sulphide, sulphur dioxide, cyanogen and sulphocyanogen compounds, and these results have been confirmed by Vertess, Bamberger, and others. Bamberger ascribes the presence of ammonia and cyanogen compounds to the nitrides and even cyanides formed in the furnace. Nitrides of aluminum and magnesium decompose in presence of water, forming ammonia. The cyanides, which he says are quickly formed when hot carbide is exposed to nitrogen, are readily decomposed by superheated steam to form ammonia. He therefore recommends maintenance of low temperature in the generator, letting the carbide fall into a large volume of cold water which will leave the aluminum nitride and the cyanides undecomposed, and by which the small quantity of ammonia liberated may be absorbed.

For the purification of acetylene many suggestions have been

made and several processes proposed. Oderheimer uses something like the Laming mixture of sawdust and iron compounds which seems to reduce the tendency of the gas to give smoky flames but it does not remove the phosphorus compounds. Lunge and Cedercreutz easily remove the hydrogen phosphide by passing the gas over wet calcium chloride and afterwards through lime to hold back the chlorine. Frank finds that the phosphorus and sulphur compounds may be reduced to a minimum by washing with acid metallic salt solutions and Pictet uses, in succession, the following liquids: (1) a very concentrated solution of calcium chloride, (2) solution of lead compounds, and (3) sulphuric acid. All the solutions are cooled to —16° C. at which temperature he finds the impurities are absorbed while the acetylene is not.

It is held that the thoroughly purified acetylene will form combinations with neither copper nor other metals, and is even less poisonous than ordinary illuminating gas; but in presence of air or moisture combinations with metals are likely to be formed, and these substances should therefore be carefully excluded.

Both Pintsch Co. and Pictet have specially studied the sensitiveness of the gas when compressed to heat and shock. The Pintsch Co. filled a vessel whose joints were soft soldered, the pressure within being six atmospheres. When heated to 200° the solder melted and the gas issuing from the opened joint burned quietly; but another vessel with hard soldered joints, likewise filled with pressure of six atmospheres, laid upon a burning wood-pile, ultimately exploded with the greatest violence. Pictet cools the gas to —20° C. as it comes from the gasometer, separates the moisture, forces it at eight atmospheres through a cooling system, bringing it to —80°, at which temperature and pressure it becomes liquid. It is stated that the containing bombs which, by the way, were fitted with brass cocks, were pierced with rifle bullets, struck with mallets, and hurled against rocks without causing explosion.

But the Pintsch Company recommends, as a further measure of safety, that for use in railway lighting the gas be mixed with oil-gas in the proportion of thirty per cent. of the former to seventy per cent. of the latter. Claude and Hess find that while acetone will dissolve at 15° C. about twenty-five times its volume of acetylene, if the pressure be increased to twelve atmospheres it will hold 300 times its volume. That is to say one liter of acetone is capable of holding 300 liters of acetylene or the quantity ordinarily liberated from one kilogram of carbide. The acetylene thus held will be given off with release of pressure until solubility at atmospheric pressure is reached. The mixture is said to be practically non-explosive, and therefore much safer

than liquefied acetylene, but it is suggested that before use it be washed to remove the accompanying acetone.

Concerning the relative efficiency of acetylene as a practical illuminating agent much has been said. Hubou finds that ordinary burners of different lighting powers consume of acetylene per candle-power hour :

	Acetylene consumed. Liters.
Burners of 1 to 2 c.p.	8
" " 2 to 5 "	7.5
" " 5 to 10 "	7.0
" " over 10 "	5.6

Pictet offers a table of comparison of cost of the various sources of light used in Paris based upon prices of illuminating material as follows : Calcium carbide, 0.4 franc per kilogram ; acetylene, 1.5 francs per cubic meter ; petroleum, 0.97 franc per kilogram ; illuminating gas, 0.3 franc per cubic meter ; incandescent electric light, 1.0 franc per kilowatt hour.

The ratios of cost of these different materials as used to acetylene are respectively as follows : Normal lamp, 4.4 : 1.2 ; petroleum round-wick lamp, 7.7 : 3.6 ; Argand gas burner, 3.8 : 1.2; Paris burners, 6 : 6 to 9 : 11.2 ; Wenham lamp, 5.1 : 5.5 ; Welsbach light, 2.6 : 3.4 and 3.6 : 5.6 ; incandescent electric, 3 : 1.2.

Wedding's table of comparisons illustrate these same relations as they appear in Germany and will be of interest :

	Candle-power.	Heat per candle-power. Cal.	Cost per hour.
Illuminating gas-slit burner	30	66.5	6.4
" round burner	20	50.	3.2
" regenerative burner	111	18.4	6.5
" incandescent burner	50	10.	1.6
Spirit incandescent lamp	30	10.6	2.0
Kerosene	30	32.0	2.2
Kerosene incandescent lamp	40	13.75	1.0
Acetylene	60	8.9	5.4
Electric light incandescent	16	2.59	2.9
" " arc light	600	0.37	15.5

These figures are less favorable to acetylene than those of Pictet.

Ten French factories are making calcium carbide for the production of acetylene gas and four are being built. France next year will produce three thousand tons of the carbide, worth $75 a ton, exclusive of the cost of packing. Two villages in France are lighted wholly by acetylene gas. Each house in these villages has its own gas plant, just as bicyclists in this country make their own gas from the carbide. The lighting power of acetylene is fifteen times that of coal gas. For the same amount of light it costs 50 per cent. less than coal-gas.[1]

[1] This paragraph is quoted from a despatch to one of the current daily journals. M.

Krämer discussing the production of benzene as a by-product of the coking industry says that the yield of 4500 to 5000 tons in a single year caused the price to fall to twenty-five marks per 100 kilograms, the quantity being three times as much as is obtained in Germany from gas-tar. To utilize the excess he recommends its admixture with alcohol, adding ten per cent. (10 : 1) for use in incandescent lamps. Frank states that the Charlottenberg Gasanstalt found that when added to illuminating gas of thirteen to fourteen candle-power, four grams sufficed to increase the lighting capacity, one candle-power. Schimming and Jaeger, found that mixed water-gas and coal-gas required seven to eight grams benzene for one candle-power increase. Krämer however showed that water-gas free from methane will not hold benzene effectively.

The discovery of Nernst that when calcium and magnesium oxides are heated they become tolerably good conductors of electricity and that when further heated by the transmission of a current they become highly incandescent is most interesting. Even at the highest white heat they are not softened or materially changed. If the carbon filament be covered with a layer of magnesium oxide and enclosed in a vacuum globe the oxide becomes heated and finally incandescent. Such a rod gives with a current of 0.25 ampère and 108 volts a light of twenty-eight Hefner candle-power or one candle-power per watt while the ordinary incandescent lamp consumes three to four watts per candle-power. The initial heating of the magnesium oxide presents difficulties, and the life of the filament is questioned.

Auer von Welsbach utilizes in his incandescent light the hitherto unknown property of osmium *in vacuo* and in a reducing gas mixture to resist liquefaction or volatilization even at the volatilization points of iridium or platinum. Since the light emission of a glowing body grows much more rapidly than its absolute temperature it is held that good light effects should be obtained by the use of osmium filaments instead of carbon filaments in the incandescent lamps. The same observer finds that platinum wire will not melt even at the most intense white heat if covered with only so much as one-tenth millimeter of thorium oxide. It would therefore appear that even more easily melting bodies than osmium may be used for the preparation of filaments to stand particularly high temperatures.

Altogether the status of the illumination problem has materially changed within the year, and decided progress may be expected in the very near future.

In the production and recovery of the nitrogen compounds, some progress has been made. It is reported that in England the production of ammonia as sulphate in 1897, from different sources respectively was as follows :

	Long tons.
From gas works	132,724
" iron "	17,729
" shale "	37,153
" coke "	10,624

It is also reported that in Europe the production in 1898 will exceed 375,000 tons of sulphate against the production of 330,000 tons in 1897. Of this, Germany and Austria produced 100,000 tons; 46,000 tons from Eschweiler and the Saar, 40,000 tons from upper and lower Silesia and Austria, and 14,000 tons from gas works.

These must remain for some time the principal sources of the ammonia compounds, yet we must expect that the utilization of other waste products may contribute at least a small share. Thus, Pieper and Fellner propose to collect the gases issuing from the dry distillation of nitrogenous organic matters as well as those from nitrogenous coke. One-third of the nitrogen passes off, they say, with the hydrocarbon gases, and the remainder is removed by superheated steam in an apparatus specially designed for the purpose.

In the fixation of atmospheric nitrogen, attention has already been called to the results of Lord Rayleigh which showed that if the nitrous compounds generated in the atmosphere be promptly removed from the sphere of action of the spark by means of an alkaline solution the yield becomes attractive. During the past year Berthelot has continued his researches in this direction. His investigations into the fixation of nitrogen by carbon compounds and particularly the carbohydrates under the influence of electrical tension such as prevails in the Siemens tubes are well known, and are of the highest interest. He has now extended them to the study of the alcohols, ethers, phenols, and similar compounds and finds that under the influence of the electric spark in an atmosphere of nitrogen containing vapors of the substances named, nitrogen is fixed and hydrogen liberated; in other words true substitution is effected, the quantity of nitrogen fixed varying with the different compounds. The action is here doubtless similar to that occurring in the Otto apparatus already mentioned and illustrates further the influence of the electrical tension upon the intensity of chemical action, adding thus to the future applications of the current.

In the production of the cyanides from atmospheric nitrogen, but little by way of suggestion or improvement has been offered. Blackmore proposes to produce cyanides, ferrocyanides, and thiocyanates by fusing together a mixture consisting of metallic sulphides and carbides, and passing nitrogen gas through the mixture. He recommends an alkaline sulphide and iron carbide for the purpose. Petschow melts alkali in a crucible and introduces nitrogen mixed with hydrocarbon gases, such as

acetylene, or with carbon dust, to the melt through an opening in the cover. He avoids excess of carbon, but does not limit the quantity of nitrogen or ammonia used. Excess of the latter is to be collected in acid, and the cyanide recovered by well-known methods. Colné, of Pittsburg, proposed a method for production of cyanide and ammonia in the following steps carried on in a closed alkali furnace: (1) burning of air and gas, (2) dissociation of liquid hydrocarbon, (3) dissociation of alkali and formation of cyanide. In connection with this, decomposition of the cyanide with superheated steam for producing ammonia. Caro passes free nitrogen over barium or calcium carbide alone, or over these substances mixed with alkali and carbon, the whole heated in a clay retort or tube to a dark red heat. Rossel and Franck heat the carbides of aluminum, magnesium, zinc, or iron in presence of nitrogen to form the corresponding nitrides.

Conroy, Hurter, and Brock convert the thiocyanate into cyanide by heating together in an autoclave under pressure, calcium thiocyanate and ferrous chloride, but preferably the thiocyanate and reduced iron in excess, with the following reaction:

$$Fe(CNS)_2 + 2Fe = Fe(CN)_2 + 2FeS.$$

The residuum is treated with soda-lye and leached to obtain sodium ferrocyanide; or the mass is treated with weak hydrochloric acid, the hydrogen sulphide collected, the ferrous cyanide washed and treated with alkali. If the ferrous chloride is used in the first process the residue from the soda leach is treated with hydrochloric acid, and the resulting ferrous chloride used as indicated.

The United Alkali Company have utilized the reaction of nitric acid with the thiocyanates for the production of pure cyanide. The solution of 20 to 30 per cent. thiocyanate is mixed with an excess of nitric acid and forced in fine spray into a closed vessel containing hot water and fitted with a stirring gear. Air must be vigorously excluded from the apparatus, the thiocyanate is broken up, sulphuric acid is formed, cyanogen gas is liberated and the latter after being washed to free from nitrous fumes is absorbed in an alkaline solution or cold water.

Nithack, of Nordhausen, undertakes the production of nitrogen compounds by the electrolysis of water charged with air, making use of an observation of Davy to the effect that under such conditions ammonia will be formed at the cathode and nitric acid at the anode. He therefore electrolyzes water charged under pressure with air and claims to so obtain ultimately a strong solution of ammonia salt.

What seems to be an improvement in the manufacture of oxalic acid has been patented in the United States and England. Woody matter is dried and heated, *in vacuo*, to 70° C. to remove

air. Hot alkali liquor is then run in upon it, the vacuum maintained, and temperature raised to 180° C. The progress of the operation is controlled by testing a sample from time to time. When the digestion is complete oxidizing substances such as hydrogen dioxide, sodium dioxide, air, or ozonized air, are introduced while the vacuum is maintained. The resulting product is treated according to the usual process of oxalic manufacture. The industrial value of the process remains to be determined.

The growing prejudice of the French medical fraternity in favor of higher value of white wines for human consumption has stimulated their production and to the extent of removing the color of wine from red grapes. To this end Martinaud extracts the juice thoroughly, aerates it until it is completely decolorized, filters it to remove the precipitated coloring-matter, and ferments the resulting liquid. The special advantage of the white wine thus made is not stated.

Buchner, of Tübingen, has made the interesting discovery that the process of alcoholic fermentation is not purely physiological and part of the vital function of the yeast plant, but is due to the influence of an enzyme produced within and secreted by the living cell. He mixed beer yeast with fine sand, ground the mass till the whole was well reduced, subjected it to pressure of 500 atmospheres, and so obtained 450 grams of juice, which was yellowish, transparent, almost clear—but sometimes somewhat opalescent—having pleasant odor and containing carbon dioxide and not a little coagulable albumen. Among other enzymes there were present invertin and maltose and glycogen hydrolyzing ferments besides oxybases. When sugar is added to the juice fermentation is set up much more quickly than with fresh yeast and the liberated gas is pure carbon dioxide. Its action upon sugar is lost in two or three days, but in presence of sugar it continues five or six days. It may be dried without losing its power. Yeasts differ considerably as regards the juices they yield and the juices of some cells have no fermenting power.

More interesting and valuable to the industry is the discovery of Dr. Calmette of Lille, France, of a micro-organism which has the power of converting starch directly into alcohol without the previous intervention of malt or other hydrolyzing agent. He practically applied his discovery in a distillery where 250 kilograms of grain gave 10,000 liter per cent. of alcohol (100 liters of absolute alcohol). If this operation and result can be duplicated it will eliminate from the distillery the use of malt and greatly diminish the cost of production of alcohol. The yield of alcohol reported is attractive being about as high as is ordinarily obtained in the distilleries of either this country or Germany and the new ferment will doubtless receive serious attention from those directly interested in the development of the spirit industry.

The promise of the production of spirit from moss, peat, waste

woody matter, etc., has not been fulfilled, and the results of Stenberg, of von Felitzen and Tollens, and of Simonsen give but little encouragement to the industry. Tollens, ascribes the unexpectedly low yields of alcohol obtained in each case to the presence of pentoses in the crude materials, which, although converted by the acid treatment, yield products incapable of alcoholic fermentation. Thus Tollens in his study of peats made determinations of the total reducing substances and of the pentoses and found that the difference between the results corresponded closely with the fermentable carbohydrates as indicated by the alcohol obtained. And Tollens' results correspond closely with those obtained by Maercker.

The process of Fritsche for producing alcohol from ethylsulphuric acid obtained from washing the ethylene from coke-oven gases has not further developed notwithstanding the possible low cost of the product and this has been ascribed to the limited supply of the raw material. It is estimated that the total theoretical production from this source could not exceed 5,000,000 gallons of absolute alcohol; but it has been suggested that a further source of ethylene would be possible in the reaction between calcium carbide in an acid solution containing zinc or some other metal, whereby it is expected that the nascent hydrogen and nascent acetylene might combine with formation of the compound sought. The resulting ethylene was to be treated after the method of Fritsche for production of alcohol. The cost of operation of this process would doubtless preclude its use even with very low cost of calcium carbide and therefore of acetylene. It is impossible to say however what the future may have in store for us in this particular, for with cheap acetylene on one hand, with cheap hydrogen from the electrolytic processes of Latchinoff, Garuti, or of Schuchert & Co., together with electrical apparatus of Otto for intensifying chemical activity, cheap and abundant ethylene may still be possible. The suggestion will doubtless be attractive to those most closely interested.

In every direction industrial progress is suggestive, and we may expect advancement in all directions with increasing intensity. Commercial artificial indigo, commercial artificial silk, commercial mercerized cotton in its various forms, the new colors and medicinal substances from the carbon compounds, new concentrated nutritive substances, synthetic albumen, the various toxines and extracts of animal matters of therapeutic value, all claim a large share of attention; and so do hundreds of other substances and processes in which the principles of chemistry find application to human needs but they must, for such discussion as this, be left to other hands and for other occasions in the hope that neither may be wanting to fill the gaps necessarily left by the present effort.

WM. MCMURTRIE.

NOTE.

Standard Pig Iron Samples.—The Committee appointed by the American Foundrymen's Association to prepare and distribute standard samples of pig iron drillings, reports that it is now able to distribute a range of samples that will meet the approval and indorsement of managers and chemists employed in the iron industry.

The standardized samples now ready for distribution cover the following determinations:

Silicon, one each of a low, medium and high range of cast iron.

Sulphur, one each of a low, medium and high range of cast iron.

Manganese, one each of a low, medium and high range of cast iron.

Phosphorus, one each of a low, medium and high range of cast iron.

Total carbon, one determination.

Graphite, one determination.

Titanium, three determinations.

In all, seventeen determinations made on four (4) samples.

The samples are designated as A, B, C, and D. Sample A, which has been ground to pass a 40-mesh sieve, gives one total carbon and one graphite. Sample B gives a low silicon, a medium sulphur, a low manganese, a phosphorus which is within the Bessemer limit, and a titanium. This has been passed through a 20-mesh sieve. Sample C gives a medium silicon, high sulphur, medium manganese, medium phosphorus, and a titanium. This has also passed a 20-mesh sieve. Sample D gives a high silicon, low sulphur, high manganese, high phosphorus, and a titanium, and has passed through a 40-mesh sieve.

The drillings were obtained from castings made after the plan described by Mr. West in his paper before the Pittsburg Foundrymen's Association, June, 1898. The drillings were prepared under the supervision of Prof. C. H. Benjamin, and the standardizing under that of Prof. A. W. Smith, both of the Case School of Applied Science, Cleveland. The chemists engaged in standardizing the four samples were Messrs. Booth, Garrett, and Blair, Philadelphia; Prof. A. W. Smith, Cremer and Bick-

nell, Cleveland, O., and Andrew S. McCreath, Harrisburg, Pa.

These samples may be obtained of Thos. D. West, chairman, Sharpsville, Pa. E. H.

NOTICE.

The regular monthly meetings of the New York Section will be held in the Chemical Lecture Room of the College of the City of New York, 17 Lexington Avenue, at 8.15 P.M. on the following dates: January 13; February 9; March 9; April 7; May 5; June 9. All chemists who may be visiting New York on the dates named are cordially invited to attend these meetings.

WM. MCMURTRIE.

NEW BOOKS.

SOAPS. A practical manual of the manufacture of domestic, toilet, and other soaps. BY GEORGE H. HURST, F.C.S. London: Scott, Greenwood & Co.; New York: D. Van Nostrand Co. Price, $5.00.

Nearly half this book is devoted to the raw materials used in the manufacture of soap. This part is very comprehensive, containing even a chapter on water as a soap material; at the same time no space is given to technically useless descriptions of those fats and oils, which are but rarely used in soap manufacture, while the position of the commoner fats in the scale of usefulness is clearly stated.

Considering the admirable arrangement of this part of the work, it is to be regretted that it is not more accurate, especially in the chemistry of the fats, for though the author has inserted abundant simple formulas and equations, many passages show that the material has been hastily compiled from the various works on this subject; for instance, with a little thought the author would have avoided the erroneous statement made on page 117 that the proportion of solid fatty acids in tallow is *increased* by the addition of cottonseed-oil stearin. Again, lard is said to contain thirty-five to forty per cent. of stearin with small quantities of palmitin, while actually, as a more careful search into the literature of this subject would have shown, the palmitin in lard is largely in excess of the stearin. Such errors are common in works on this subject, but it is time that they were weeded out.

One chapter is devoted to "Soap Machinery," and another to the "Technology of Soap-Making." This subject, always difficult to treat in a manual, gives the novice a clear view of the principles and practice of soap-making.

In the analysis of soap the author shows himself to be entirely at home, writing from his own experience. Indeed, a single brief chapter of more use to the soap chemist can hardly be found anywhere. The practice of calculating the alkali combined with fatty acid as Na or K instead of the time-worn Na_2O and K_2O, is to be commended; for, besides being the modern and rational view of the composition of alkaline salts, it allows the fatty acid to be entered in the analysis as such, instead of as hypothetical anhydride, the total, on footing up the analysis, being only a trifle over 100, due to the acid hydrogen of the fatty acid.

A very brief chapter is given to the recovery of glycerine from lyes, and an appendix is added with the common specific gravity and hydrometer tables. E. TWITCHELL.

BOOKS RECEIVED.

Some Notes on Chemical Jurisprudence. A digest of patent-law cases involving cases. By Harwood Huntington, 260 West Broadway, New York City. Price, 25 cents.

Outlines of Industrial Chemistry. A text-book for students. By Frank Hall Thorp, Ph.D. New York: The Macmillan Co. 1898. xx+541 pp. Price, $3.50.

Preliminary Report of an Investigation of Rivers and Deep Ground Waters of Ohio as Sources of Public Water Supplies, by the State Board of Health, 1897-1898. Cleveland, Ohio. 1898. 259 pp. with maps.

A Report of Progress of Investigations in the Chemistry of Wheat. By G. L. Teller. Bulletin No. 53. Arkansas Agricultural Experiment Station, Fayetteville, Ark. September, 1898. 30 pp.

Report on the Investigations into the Purification of the Ohio River Water at Louisville, Kentucky, made to the President and Directors of the Louisville Water Company. By George W. Fuller. New York: D. Van Nostrand Company. 1898. 4to. vii+461 pp. Price, $10.00.

Digest of Criticisms on the United States Pharmacopoeia: Seventh Decennial Revision (1890). Part II, comprising abstracts of papers up to December 31, 1897. viii+146 pp. Published by the Committee of Revision and Publication of the Pharmacopoeia of the United States (1890-1900).

Chemische Technologie an den Universitäten und technischen Hochschulen Deutschlands. Von Dr. Ferdinand Fischer, Professor an der Universität Göttingen. Braunschweig: Friedrich Viewig und Sohn. vi+54 pp. Price, M 1.25.

Report of the Secretary of Agriculture. 1898. Washington: Government Printing Office. 1898. 60 pp.

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